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TRAINING EQUIPMENT REQUIREMENTS FOR APOLLO SPACECRAFT [U]

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22 March 1962
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Prepared By

Training Systems Requirements
APOLLO - GSE

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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TRAINING EQUIPMENT REQUIREMENTS FOR THE APOLLO SPACECRAFT

1. SCOPE

This report defines the training equipment required in support of the Apollo training program. The equipment will facilitate the training of spacecraft crew and maintenance personnel individually, or as coordinated teams to fulfill the training requirement.

2. DESIGN AND PERFORMANCE REQUIREMENTS

2.1 Design Requirements

The training equipment will reflect minimum design and maximum flexibility and, where practical, utilize all state-of-the-art advancement occuring during the development period.

2.2 Performance Requirements

Trainer performance characteristics will be commensurate with the information on the spacecraft performance characteristics as accrued during the trainer development period.

3. TRAINING EQUIPMENT DESCRIPTION

Individual trainer descriptions and general performance characteristics will be as specified herein. Emphasis will be placed on simplicity, minimum size, versatility, ease of maintenance, and minimum time for problem generation.

[redacted]

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3.1 Part Task Trainers (Crew Trainers)

The part task trainers will be designed to facilitate the attainment and maintenance of crew proficiency in the techniques and procedures associated with the management and control of the Apollo spacecraft. Each trainer will provide procedural training for only those tasks directly related to a specific mission segment. Each trainer will be completely independent of any other trainer and will include instructor - operator consoles, computing equipment, and power supplies, as required. Individual trainer configurations are dependent upon the tasks to be performed and will be as described in the following paragraphs.

[redacted]

3.1.1 Attitude Control Trainer (T14-860002)

3.1.1.1 Description

The Attitude Control Trainer will provide training for the spacecraft crew in the technique of control device manipulation to achieve and/or maintain a desired attitude of the spacecraft. The trainer will provide a realistic replica of the pilot seat, the pencil stick, the rudder pedals, all other controls and switches directly related to attitude control, and all instruments related to attitude indication of the spacecraft. All attitude controls and indicators will be operable and will exhibit the same dynamic characteristics as the corresponding equipments in the actual command module. The trainer will be a fixed base trainer. Provisions will be incorporated for adjusting the dynamic response of the indicating instruments from the maximum attainable rates (free space condition) to rates corresponding to those attainable in the command module during re-entry. Provisions will be incorporated for injection of transients and disturbances characteristic of equipment responses under malfunction conditions in the actual spacecraft. The trainer will include a modified command module, the instructor's equipment console, peripheral computing equipment bays, utility equipment bays of power and ventilation systems, assembly structure, and interconnecting cabling.

The physical construction of the command module will be accomplished in such a manner that it can be opened up into three (3) sections. This will allow ease of accessibility to interior equipment for maintenance purposes.

3.1.1.2 Performance Capabilities

The Attitude Control Trainer will be designed to provide man oriented training to display the effect of acceleration, velocities, and forces for any given Apollo spacecraft configuration. Reaction control and propulsion control forces applied to the spacecraft will be simulated in conjunction with the stabilization and control system, and with manual control capability. The simulation will provide training in two basic categories, program selection to provide automatic control and manual control. The trainee will be instructed in spacecraft control, with system and partial system failure features. Attitude control training is conceived as training both in and out of earth environment; however, it will not include re-entry. It will include earth orbit, mid-course, and lunar environment problems, as related to attitude control.

Noise and vibration will be simulated to provide realism in the simulated operational control of the spacecraft.

3.1.1.2.1 Spacecraft Systems Functional Analysis

The following spacecraft functional parameters are applicable for the design of the Attitude Control Trainer:

CONTROLS APPLICABLE

- Attitude Stick (pitch and roll)
- Rudder Pedals (yaw)
- Auto Control System (auto pilot)
- Mode Selector Switch(es)
- ON-OFF Switch(es)

[redacted]

Gain Controller

INSTRUMENTS AFFECTED

Flight Director Attitude Indicator Group

Roll Rate

Roll Displacement

Yaw Rate

Yaw Displacement

Pitch Rate

Pitch Displacement

IAS, Pressure Altitude and Altitude Rate Indicator

DECISION RESPONSES

Transfer from Automatic to Manual Control

Correct for deviations from normal or predicted attitude

Determination of direction of correction

Determination of rate of correction

Maneuvers for observation

Maneuvers preparatory for re-entry

RESPONSE CHARACTERISTICS

Synthesize instrument response rates as function of control manipulations.

Synthesize forces and response characteristics of control actuation devices (stick and rudder).

3.1.1.3 GENERAL EQUIPMENT REQUIREMENTS

[redacted]

3.1.1.3.1 Simulated Command Module

The simulated command module will be designed to provide the pilot-commander attitude control training environment, in which any attitude control functions external to the pilot-commander environment will be provided as instructor support functions.

The simulated command module will consist of controls and displays required for effective monitoring and control of the attitude of the simulated spacecraft. The training environment will include all controls and displays located and associated to appear the same as in the actual command module. The instruments and controls required for training will include a primary action group and an information group. The primary action group is that group through which pilot action/response is exercised. The information group is that group from which the pilot receives information.

The module will be constructed in such a manner that access for maintenance and operation is maintained without any deterioriation of the training environment.

3.1.1.3.2 Instructor Control Station

The instructor control station will include problem control and trainee evaluation equipment. The computing system will be controlled from this station via analog and digital formats. The task of programming operations will be performed utilizing equipment included for this purpose. The instructor control station equipment will provide problem management capability to present, monitor, alter, and evaluate programmed instruction for the astronaut trainee.

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The instructor console will provide equipment for two place operation and control. One station will provide information read-out utilizing duplicate instrumentation of the command module, with associated logical malfunction insertion capability. The other station will provide routine and sub-routine program instruction equipment, with monitor and evaluation equipment. Associated between both stations, system status and logical data insertion status indicators are provided for instruction back-up and program scheduling.

The instructor console will be curved, and accomodates two instructors. One instructor will control program, communication, and evaluation equipment, while the other will be concerned with the training of the astronaut directly. A set of instrumentation will be provided for the latter instructor's station, being duplicates of the command module or pilot instrumentation. Additional controls are provided for the control of the training problem. These controls are located in the middle area between instructor stations in such a manner that either instructor may effect operation.

3.1.1.3.3 <u>Computing Equipment</u>

A computer system will be furnished to provide the attitude control problem, which is determined by spacecraft configuration, and task requirements. The spacecraft configuration will determine moments of inertia, location of center of gravity, propulsion system employed, and reaction control system selected use. Thrust vector control, utilizing Vernier engines combined with mission propulsion system firing (in the case of the service module), will be simulated as it

[redacted]

[redacted]

affects attitude control. Thrust vector control, utilizing the terminal propulsion system in conjunction with the main propulsion system (in the case of the lunar landing module), will be simulated as it affects attitude control.

The command module and service module reaction control systems may be manually or automatically controlled. In the actual craft the stabilization and control system provides automatic control. In manual operation, the pilot will control these systems directly. The separate and selected use of these systems will be simulated.

The computer provided to simulate the attitude characteristics of the spacecraft will be an analog device with a supporting digital programmer. The analog computer will provide spacecraft dynamic characteristics in earth, midcourse, and lunar environments. Each environment will require particular spacecraft characteristics. Spacecraft configuration features for each environment may be changed at trainee option, such as abort requirements programmed for training. Under these conditions the computing equipment will be under program control through the digital programmer.

The digital programmer provides a means for encoder and logical inputs, and for compatible digital scaling of instrumentation in the command module. It also provides a means for instruction format introduction from the instructor's station; that is, program and sub-routine programming is afforded at instructor option.

The programmer will provide logic control input data to the command module and to the computer when required to provide automatic features simulating off-loading of spacecraft weight, malfunction of engines, change of center of gravity, change in moments of inertia, and the control of light indications on command module and instructor station console panels. Any scale changes of trainee control quantities due to environment or spacecraft configuration will be controlled automatically through the digital programmer. To provide the different earth, midcourse and lunar environments, the computer configuration will change. To provide the different spacecraft configurations, the computer configuration will change. Since abort requirements obviate the change in spacecraft configuration in any environment, computer configuration changes occur as interacting between environment and spacecraft configuration. These interacting computer configuration changes affect corresponding vehicle dynamic characteristics, and ultimately affect the control characteristics. Spacecraft configurations are (1) command module alone, (2) command and service module, (3) command module, service module, adapter, space laboratory and (4) command module, service module, adapter, and lunar landing module.

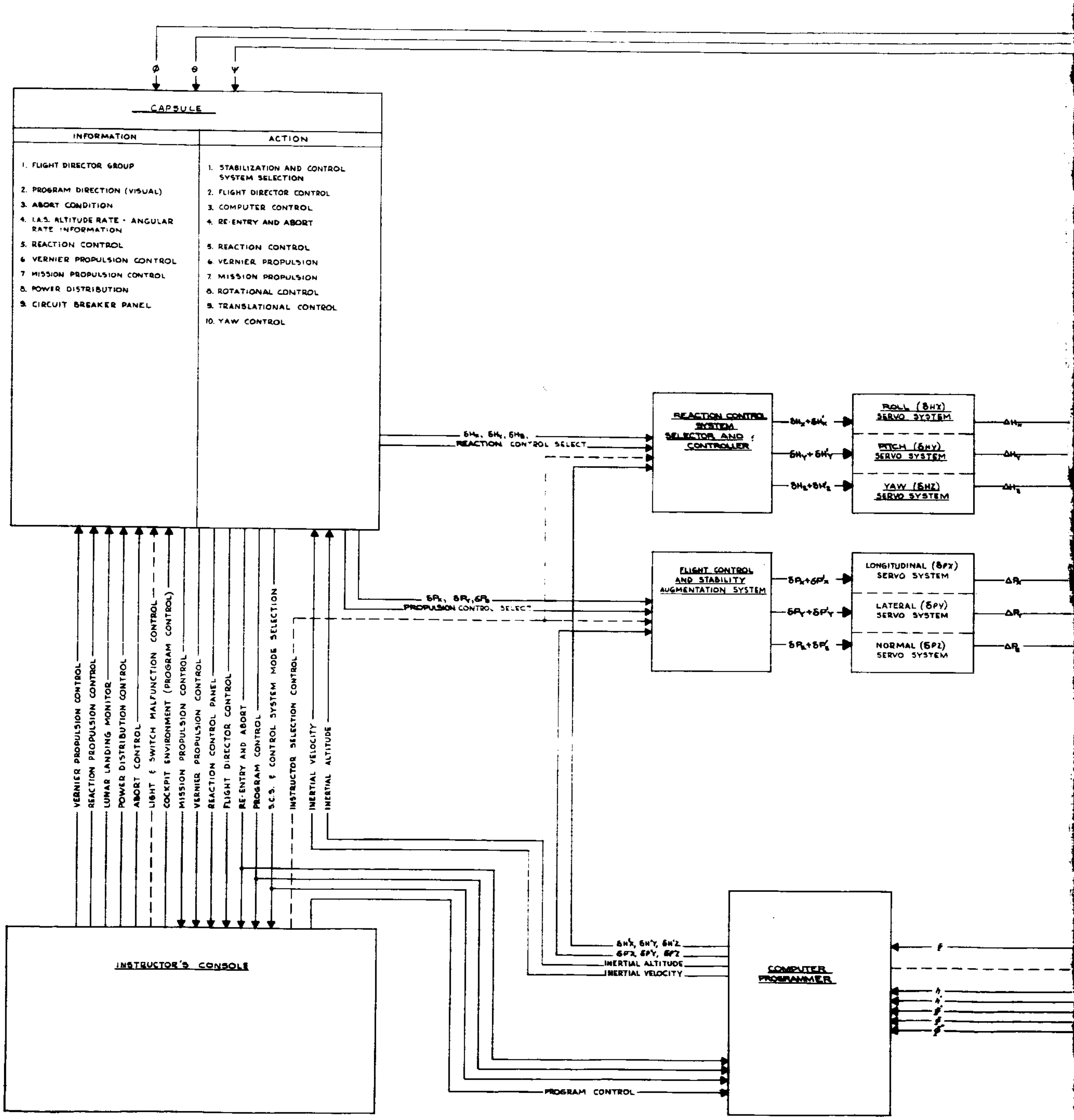
3.1.1.3.4 <u>Ventilation Equipment</u>

The trainer design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates so as to prevent excessive temperatures in their immediate environment. Normal convection will affect the dissipation of heat generated by electronic components. Where the rate of heat dissipation is too high to warrant reliance upon normal convection for cooling, forced ventilation will be installed.

[redacted]

3.1.1.3.5 Power Equipment

Power generation, distribution and control equipment will be provided as required.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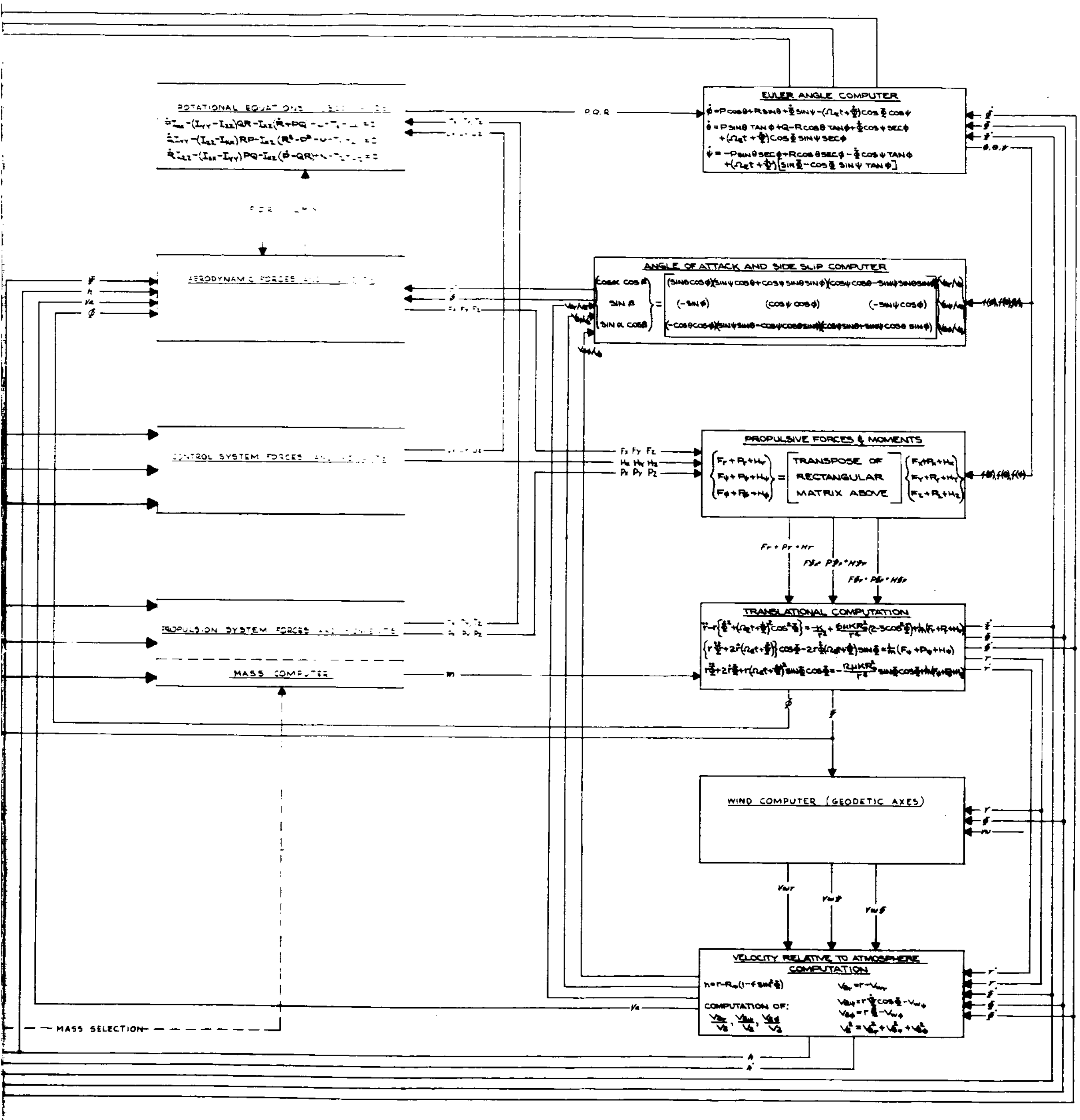
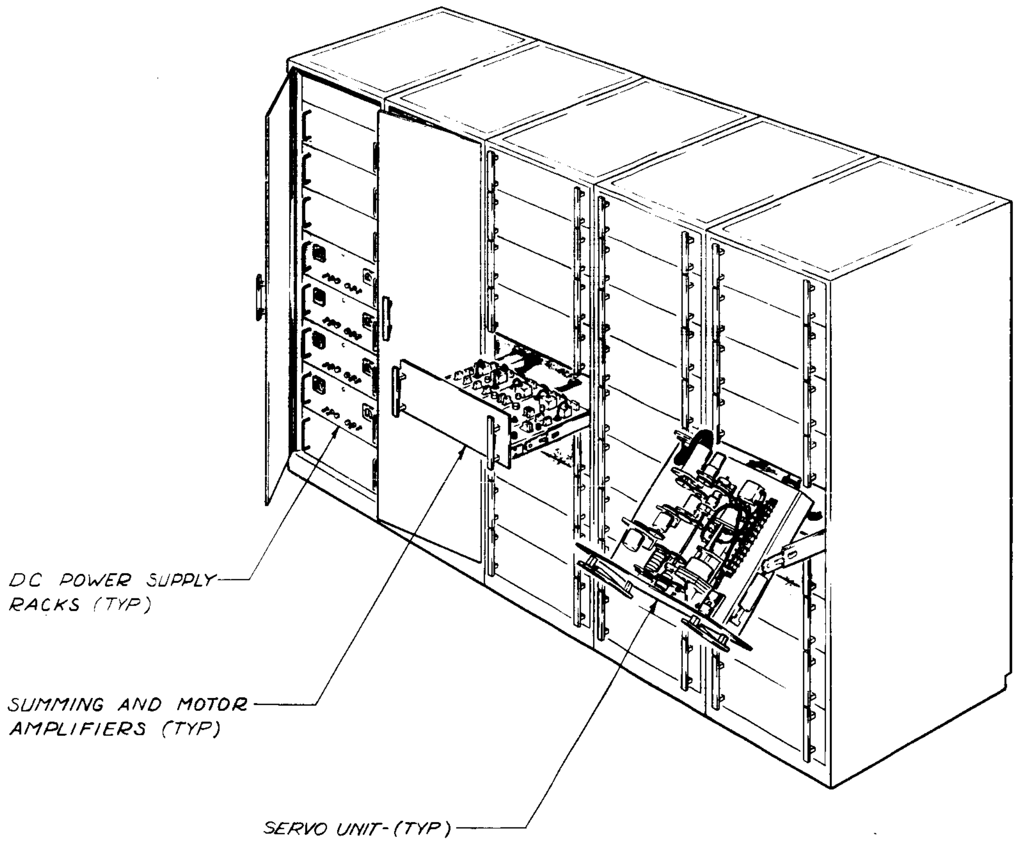
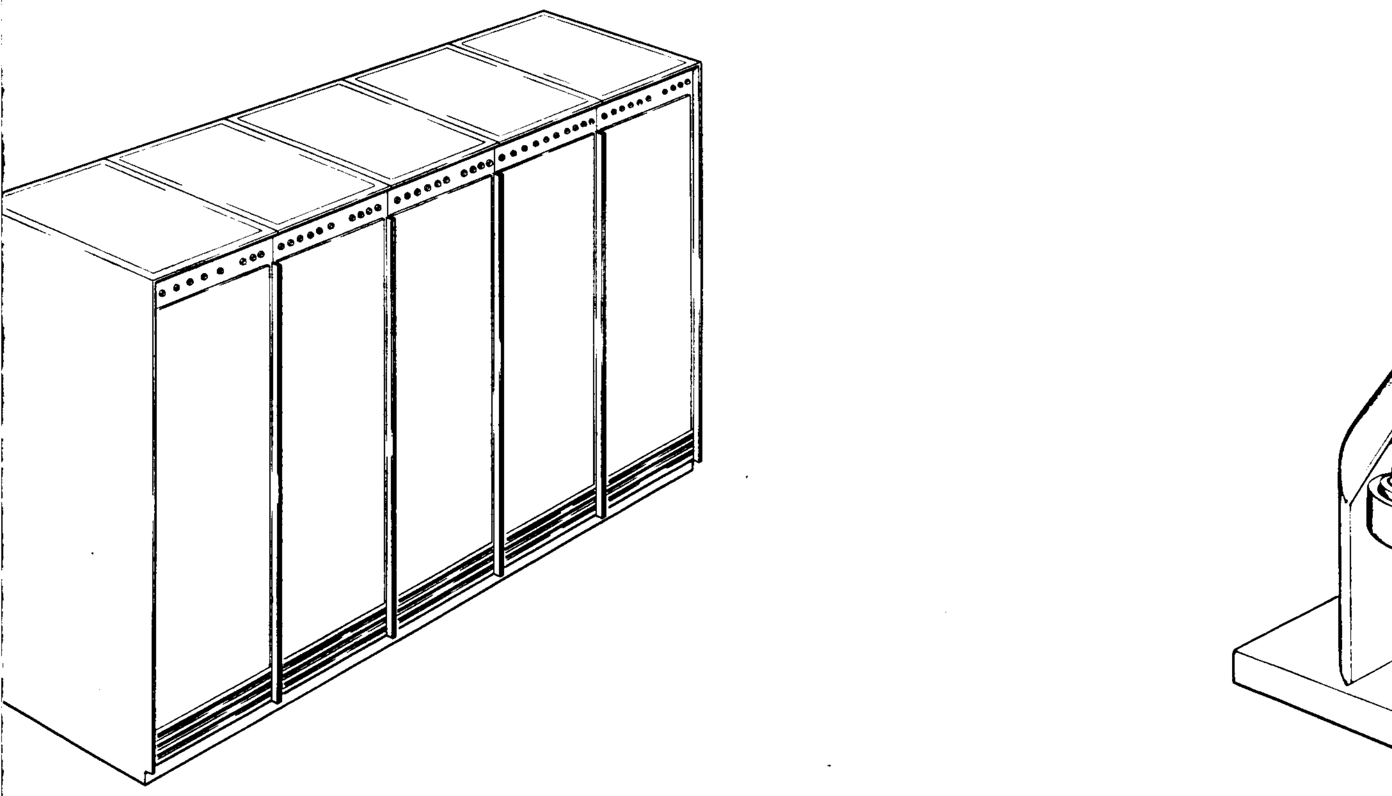
CAPSULE
INFORMATION
1. FLIGHT DIRECTOR GROUP
2. PROGRAM DIRECTION (VISUAL)
3. ABORT CONDITION
4. I.A.S. ALTITUDE RATE - ANGULAR RATE INFORMATION
5. REACTION CONTROL
6. VERNIER PROPULSION CONTROL
7. MISSION PROPULSION CONTROL
8. POWER DISTRIBUTION
9. CIRCUIT BREAKER PANEL
ACTION
1. STABILIZATION AND CONTROL SYSTEM SELECTION
2. FLIGHT DIRECTOR CONTROL
3. COMPUTER CONTROL
4. RE-ENTRY AND ABORT
5. REACTION CONTROL
6. VERNIER PROPULSION
7. MISSION PROPULSION
8. ROTATIONAL CONTROL
9. TRANSLATIONAL CONTROL
10. YAW CONTROL
δHx, δHy, δHz, REACTION CONTROL SELECT
REACTION CONTROL SYSTEM SELECTOR AND CONTROLLER
δHx+δH'x
δHy+δH'y
δHz+δH'z
ROLL (δHX) SERVO SYSTEM
PITCH (δHY) SERVO SYSTEM
YAW (δHZ) SERVO SYSTEM
ΔHx
ΔHy
ΔHz
δRx, δRy, δRz, PROPULSION CONTROL SELECT
FLIGHT CONTROL AND STABILITY AUGMENTATION SYSTEM
δPx+δP'x
δPy+δP'y
δPz+δP'z
LONGITUDINAL (δPX) SERVO SYSTEM
LATERAL (δPY) SERVO SYSTEM
NORMAL (δPZ) SERVO SYSTEM
ΔRx
ΔRy
ΔRz
VERNIER PROPULSION CONTROL
REACTION PROPULSION CONTROL
LUNAR LANDING MONITOR
POWER DISTRIBUTION CONTROL
ABORT CONTROL
LIGHT & SWITCH MALFUNCTION CONTROL
COCKPIT ENVIRONMENT (PROGRAM CONTROL)
MISSION PROPULSION CONTROL
VERNIER PROPULSION CONTROL
REACTION CONTROL PANEL
FLIGHT DIRECTOR CONTROL
RE-ENTRY AND ABORT
PROGRAM CONTROL
S.C.S. & CONTROL SYSTEM MODE SELECTION
INSTRUCTOR SELECTION CONTROL
INERTIAL VELOCITY
INERTIAL ALTITUDE
INSTRUCTOR'S CONSOLE
δH'x, δH'y, δH'z
δP'x, δP'y, δP'z
INERTIAL ALTITUDE
INERTIAL VELOCITY
COMPUTER PROGRAMMER
PROGRAM CONTROL

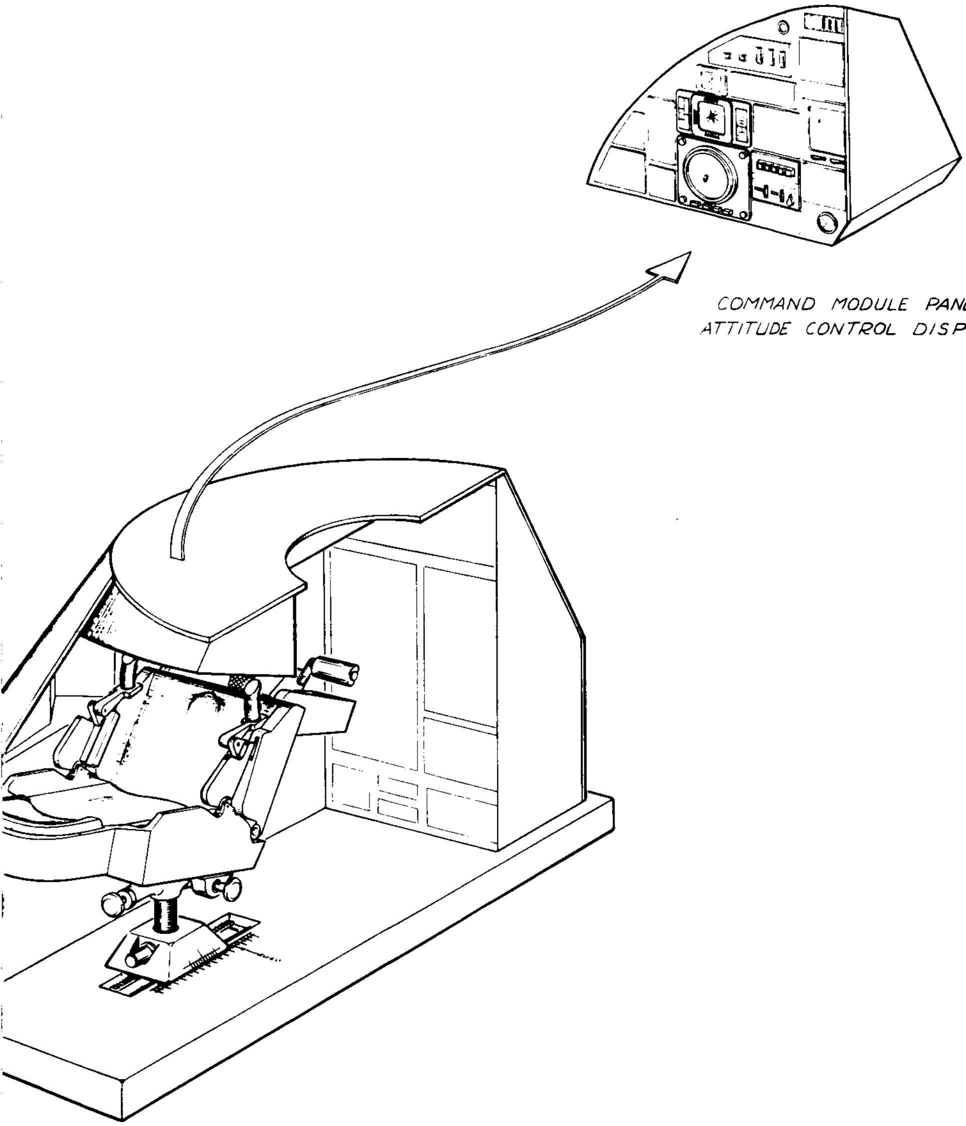


FUNCTIONAL DIAGRAM - A[illegible]DE CONTROL TRAINER



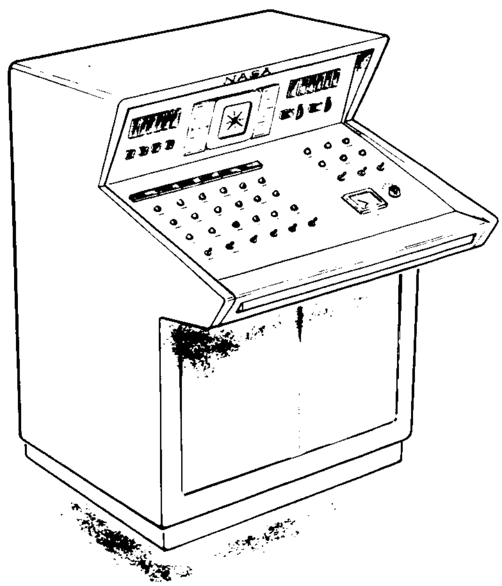
COMPUTER EQUIPMENT CABINETS





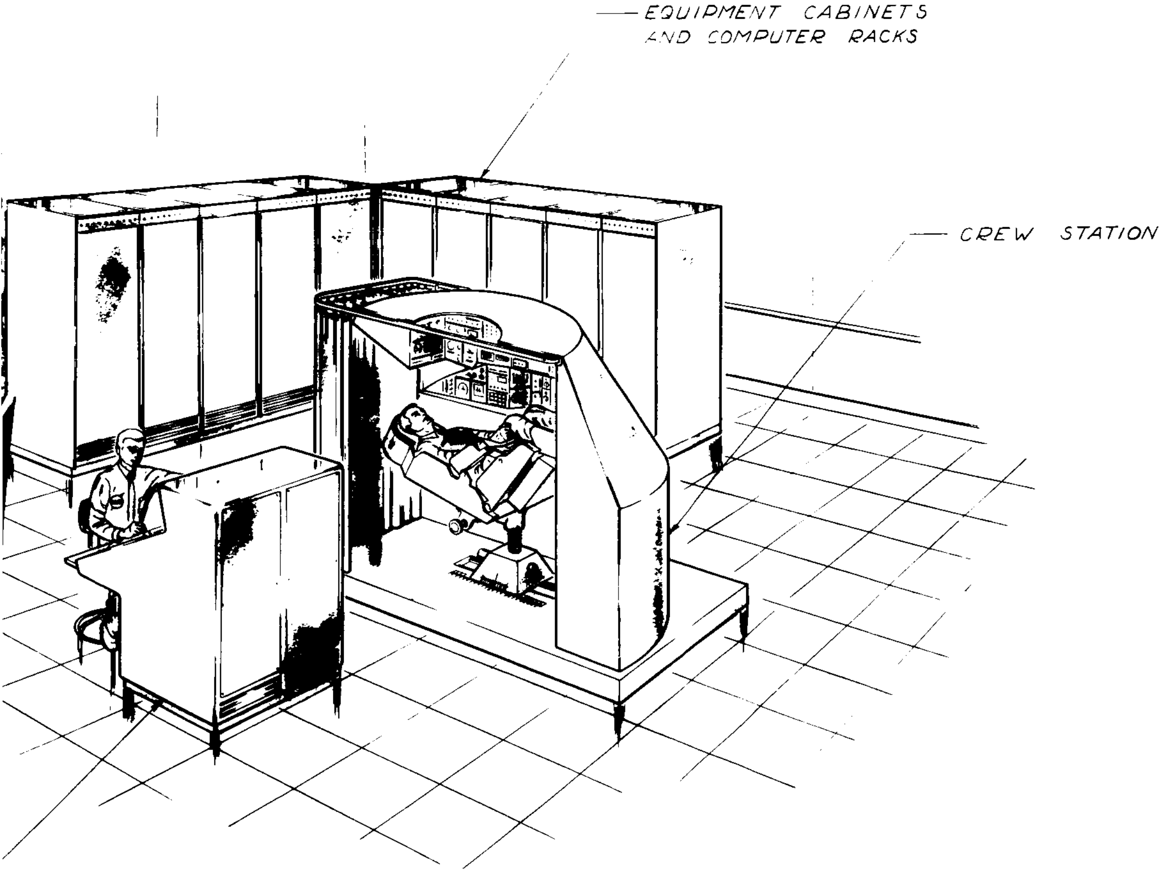
COMMAND MODULE PANELS
ATTITUDE CONTROL DISPLAYS

CREW STATION



INSTRUCTOR/MONITOR CONSOLE

INSTRUCTOR/MONITOR STATION



ATTITUDE CONTROL TRAINER
OPERATIONAL ARRANGEMENT

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2 CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK — DISPOS		

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA: SPECIFICATION SIZES, NOTES, VENDORS	ZONE	LINE NO.
												045
												044
												043
												042
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												003
												002
							T14-860002	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
REQD PER END ITEM				EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS ANGLES
.XX= ± .03
.XXX= ± .010 ±.30'
HOLES NOTED "DRILL"
[illegible]

DO NOT SCALE PRINT

DR BY	J.B.ERICKSON	3-1-62
CHK BY		
APPROVED BY		

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER-ATTITUDE CONTROL, PART TASK

CODE IDENT NO.	SIZE	
03953	J	T14-860002
SCALE		SHEET

3.1.2 Propulsion Control Trainer (T14-860003)

3.1.2.1 Description

The Propulsion Control Trainer will be designed to provide training for Apollo astronauts in propulsion system selection and operation to perform attitude and orientation tasks. The training provided will be integrated training, combining the astronaut in the operation of the reaction control and the propulsion control system with visual observation of instrument indications.

Physically, the trainer will consist of a simulated command module, computer and power equipment bays, and instructor station equipment. The computer equipment bays will include analog and digital simulation equipment. The computing equipment will integrate the control actions of the astronaut trainee and the instructor providing a realistic dynamic movement of the spacecraft through instrumentation within the command module. Simulation of sound and vibration within the command module will serve to increase a realistic simulation of the command module environment.

Instructor station monitor and problem control functions will be introduced into the command module and computer complex. The instructor's station will have duplicate instrumentation of the command module, with independent controls to perform monitor and control functions.

[redacted]

3.1.2.2 Performance Capabilities

The Propulsion Control Trainer will be designed to simulate the operation of the reaction control systems, the propulsion control systems, the Vernier propulsion system, terminal propulsion system. The design will allow both astronaut and instructor control of these systems. This simulation will include all possible spacecraft configurations, as:

(1) Command Module

(2) Command Module and Service Module

(3) Command Module - Service Module - Space Lab

(4) Command Module - Space Lab (rendezvous)

(5) Command Module - Service Module - Adapter - Lunar Landing Module

Computing equipment will be designed to provide instrument indication of dynamic movement of the spacecraft. The given or selected configuration of the spacecraft will be programmed into the computing complex. The dynamic characteristics of the spacecraft will change with the selection of the spacecraft configuration. The computer systems will receive inputs for various spacecraft configurations. Computing different center of gravity effects, different moments of inertia, and different products of inertia effects, will be accomplished in the real time solution of these different dynamic problems. The changes in dynamic characteristics due to spacecraft configuration and off-loading of mass will be observed through instrument indication at the command module and instructor station instrument panels. This design will afford

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realistic spacecraft attitude and orientation control training for the astronaut.

The simulation of earth environment and lunar environment reaction and propulsion control problems are necessary for Apollo Phase A, Phase B, and Phase C training. The selection of these computed environments will be initiated by the instructor as part of the programming of training schedules. With this selection capability, the computer complex will produce a real time solution for the particular propulsion control problem selected. The computer complex will provide six degrees of dynamic freedom of movement in both earth and lunar environments. At the instructor's option the selected propulsion problem in either environment will be under the control of the astronaut trainee.

The instructor will be able to provide discrete malfunction insertion and abort malfunction conditions. Capability for inserting malfunctions will be required at the instructor's console. These inserted malfunctions will affect functional parts and systems of the spacecraft. As a result of this program of inserted malfunctions, the astronaut will be required to properly exercise procedures to provide alternate methods of propulsion control. Through observation of the astronaut activity within the command module the instructor can provide training instructions more specifically and rapidly. Communication with the astronauts will be established by the instructor by simulation of the actual command module intercommunications system. The intercommunication control exercised by the astronaut will be the same as in the actual command module.

3.1.2.3 General Equipment Requirements

3.1.2.3.1 Simulated Command Module

The simulated command module provided for the Propulsion Control Trainer will be designed to provide the actual physical environment for the astronauts. The command module will be designed to provide adequate access in the interest of maintenance and preventative maintenance. The design will afford the insertion and removal of equipment with ease.

Included in the command module will be the pilot's and engineer's seats. The simulated instrument panel will be located in correct relation to the seats. The instrumentation on the instrument panel needed for the Propulsion Trainer will be activated by the computer. Instruments not used for propulsion will be included in the proper relationship but will not be activated.

Peripheral equipment within the physical limits of the astronauts, and equipment which the astronaut will associate visually will be included. The equipment will be representative of the equipment in the actual command module with respect to size, color and location.

3.1.2.3.2 Instructor - Operator Station

The instructor control console will provide for problem programming capability, problem monitoring capability, and problem evaluation. Problem programming capability will be afforded through logical inputs. These will be inserted at the option of the instructor or according to the training schedule format.

Problem monitoring capability will include status lights and instrument panel repeater instruments. Through the use of communications and those items listed, the instructor will be required to instigate, maintain, evaluate, and re-program the training problems during their scheduled progress.

Problem evaluation equipment will be included as specified during finalization of the propulsion trainer design, and in accordance with human factor studies. It is expected this equipment should provide methods for meaningful evaluation of astronaut training proficiency.

Instructor - Operator station indications, displays, and controls will be devised and designed to provide instructor control of the training program. This equipment concept will allow versatile and flexible control in the interest of routine and selected sub-routine programming at appropriate times in a real time training problem.

3.1.2.3.3 Computer and Peripheral Equipment

The computing system designed and employed to present the dynamic training problems to the astronauts will be a hybrid computer system. Digital and analog techniques will be employed to effect astronaut and instructor control of the computing complex.

For solution of Euler Angle computation as applied to rotational angles, velocities, and accelerations, the analog equipment will be employed. Translational problems involving distances, velocities, and accelerations will utilize digital techniques.

[redacted]

For controls of the logical and dynamic input-output of the command module and computer equipment, a digital programmer will be used. Instructor control equipment and command module equipment employed will be partially exercised through a digital programmer. Direct control functions will not necessarily be routed through the digital programmer.

Sound and vibration simulation equipment will be included in the computing equipment. This will employ electronic and electro-mechanical techniques to provide sound simulation.

3.1.2.3.4 Air Conditioning Equipment

Air conditioning equipment will be employed to cool computer equipment as well as trainee and instructor control areas. The air conditioning system should include humidity control to avoid sub-tropical organic growth within components of the computing equipment. The system will provide for complete environmental control, providing optimum ambient temperature and humidity standards.

3.1.2.3.5 Power Equipment

Power generation, distribution and control equipment will be provided as required.

[redacted]

3.1.3 Earth Re-Entry Trainer (T14-860004)

3.1.3.1 Description

The Earth Re-Entry Trainer will simulate the re-entry phase of an earth return mission. The re-entry phase will start at the point of service and command module separation which occurs at approximately 4000 N.M. altitude, and will continue through a pre-determined flight path to earth touch down. During this phase, the Re-Entry Trainer will simulate actual flight conditions of the command module only. Starting at the separation point, the re-entry flight path is as follows:

a. Maneuver of the command module to assume correct entry position (Blunt face forward).

b. The -6.4° entry angle approach at 400,000 ft altitude (entry interface).

c. Command module pre-cooling mode.

d. Activation of the re-entry oxygen supply.

e. Recovery system activation at 100,000 ft altitude (recovery interface).

f. Deployment of drogue and main chutes.

g. Deployment of recovery and survival equipment.

h. Activation of heat shield and impact devices.

i. Touchdown (landing).

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The Re-Entry Trainer will be a fixed base trainer and will provide for the integrated training of a three man (pilot, co-pilot and engineer), crew in all phases of re-entry to develop techniques and skills in control manipulation relative to the automatic or manual piloting of the spacecraft. The trainer will consist of a simulated command module, instructor - operator console station, visual simulation equipment, computing and peripheral equipment, air conditioning and environmental equipment, electrical power equipment, communications equipment, recovery and survival aids, recording and monitoring equipment and assembly structures.

Provisions will be incorporated for adjusting the dynamic indicating instrument response from maximum attainable rates to corresponding rates in the spacecraft during re-entry. Other provisions will be available in the trainer for the injection of transient disturbances under malfunction conditions occuring during actual spacecraft flight. Ingress and egress of the trainer will be through a walk in door. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.1.3.2 Performance Capabilities

The Re-Entry Trainer will be capable of astronaut training through all re-entry flight phases, maneuvers, control problems, and emergency situations as listed below:

[redacted]

Service Module Separation	Manual Flight Control
Orientation Maneuver	Navigation
Environmental Activation	Communications
Corridor Approach	System Malfunction
Pull Out Maneuver	Recovery Equipment Deployment
Automatic Flight Control	Survival Aids Deployment

The trainer will simulate the actual spacecraft performance during re-entry including the effects of acceleration, velocity and g forces by instrument and computer responses. The spacecraft attitude and position will be computed continuously and will be capable of real time sequencing during the re-entry phase. All instruments displayed will be computer driven with dynamic responses and accuracies typical of actual spacecraft instruments and components. For the simulation of the reaction (propulsion) system, computing equipment will be utilized. This will be analog computing equipment utilizing digital programming to reach compatibility between the computer and digital instrumentation of the module. Simulation will also be in conjunction with the stabilization control system and manual control through the pilot's hand and foot controllers. This will provide training in both automatic and manual control in the event of partial or complete system failure. Simulation of Deep Space Instrument Facility (DSIF) and Ground Operational Support System (GOSS) data will be provided. Of the various systems making up the Apollo missions, only the following control systems are in operation during the re-entry phase.

Guidance and Navigation System

Stabilization and Control System

Service Module Reaction Control System

Command Module Reaction Control System

Environmental Control System

Electrical Power System

Communications System

Instrumentation System

To avoid redundancy, only those portions of each system having basic functions during the re-entry phase will be actively included in the Re-Entry Trainer concept. The trainer will duplicate these functions to the extent of utilizing actual system components modified as necessary for training, or by simulation techniques where system degradation is not compromised. The trainer will be capable of providing facilities for in-flight detection, isolation and replacement of malfunctioned equipment.

3.1.3.2.1 Control Systems Functions

The following spacecraft functional parameters are applicable to the Re-Entry Trainer design.

Controls Operable	Instruments Applicable
Attitude Hand Controllers	Guidance and Navigation
Attitude Foot Pedals	Computer
S.C.S. Mode Selector	Printer
Flight Director Indicator	Stabilization Control
Computer Control Panel	Flight Director Group

Controls Operable	Instruments Applicable
Re-Entry - Abort Display	Reaction Control
Inertial Platform Control	Survival Indicator
Correction Panel	Distance - Time - Velocity
Circuit Breaker Panel	Pressure Altimeter
Cabin Lighting Switches	Power Distribution
Audio Panel	I.A.S. Altitude Angular Rate
Communications Panel	Trajectory Error
S.C.S. Adjustment	Environmental Control
Recovery Aid Deployment	Vehicle Attitude
	Telecommunications
	Periscope
	TV Monitor
	System Status Lights

3.1.3.3 General Equipment Requirements

To provide for the complete and effective training of a three man crew, the Re-Entry Trainer will require the following minimum major assemblies, components and equipments.

3.1.3.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the actual command module with regard to the interior arrangement. The interior configuration will include all controls, displays, equipment, crews quarters, etc. All equipment and control systems pertinent to re-entry will be actual flight units where practical, or operational modifications. All other equipment will be mocked up in actual size and installed in correct cabin location. Viewing

[redacted]

windows, hatches and such structures necessary for complete simulation will be duplicated. Due to the extreme high temperatures encountered externally during actual command module re-entry, provisions will be made through an environmental air conditioning system to simulate the anticipated environment within the simulated command module. The simulated command module will be constructed in such a manner that access for maintenance and operation is easily maintained without any deterioration of the equipment. The external configuration will be duplicated only to the extent for providing realistic training procedures. Noise and vibration peculiar to the re-entry phase and experienced in the actual spacecraft will be reproduced within the simulated command module.

3.1.3.3.2 Instructor'- Operator Station

The instructor - operator station will consist of an integrated arrangement of consoles, display panel boards and graphic displays. The console panels will contain controls, displays and repeater indicators to effectively monitor the re-entry training phase. Controls, displays and indicators will be identical to those simulated in the command module. Provisions for problem management will be made at the instructor's station to introduce system malfunctions, failures, emergency conditions and various control problems for presentation to the crew. The recording, evaluation and monitoring of crew actions to simulated problems will be provided.

The computing system will be controlled from this station. The instructor - operator station will provide for and consist of two consoles. One console or panel group will provide for the utilization of duplicate simulated command module instrumentation resulting in the monitoring and evaluation of crew flight actions as performed within the command module. A second console will provide routine instruction program inputs by the instructor to introduce commands to the training crew. Associated with the two consoles, a display panel board containing systems status data and logical data status indicators is provided for instruction backup and program scheduling. Sufficient controls, displays, counters, TV monitors, recorders, readouts and other necessary equipment for complete crew training will be provided. Intercommunication facilities between instructor and crew and adequate work areas will be provided.

3.1.3.3.3 Graphic Display Panel

A graphic display panel will be provided to exhibit a moving trajectory profile time-distance plot of the re-entry track displaying altitude and range in the direction of flight path and range in the direction across the flight path. This equipment will be analog servo mechanism driven by the computer system from the pilots control action within the command module.

3.1.3.3.4 Visual Simulation Equipment

The visual simulation equipment will provide all visual presentations to the crew as applicable to the re-entry phase. The programmed re-entry phase will originate from a real time solution of the problem. The equipment will be analog or high resolution digital servo mechanism driven by the digital computer system. The equipment will provide a celestial display and earth situation display of sufficient accuracy to permit the use of the astral-sextant for navigational observations. The visual display system will provide coordinated window, periscope, and astral sextant viewing in such manner that realistic representation is obtained. The earth presentation will be of sufficient resolution that observation of surface detail will correspond to a viewing distance of 4000 nm altitude to a distance 400,000 ft altitude and for presenting the earth display in the proper size relationship corresponding to the computed spatial position of the spacecraft. Provisions will be made for presenting movement into and out of the fields of view. Transmission of visual information from visual display simulation equipment to the crew observation facilities (windows - periscope-astral sextant) will be by light optical techniques or approved equivalent. Transition through various presentation scales will be smooth to the point of minimum crew detection.

3.1.3.3.5 Computers and Peripheral Equipment

Computers and peripheral equipment will consist of analog and digital computers, programmers and signal conditioners. Digital computers will accept program control routine and sub-routine functions and will serve as a master control of the computer complex. A digital programmer will program the computing equipment and provides a means for encoder and logical inputs and compatable digital scaling of instrumentation in the simulated command module. It also provides a means for instruction format introduction from the instructor - operator station to afford option of program routine or sub-routine programming action. The programmer will provide logic control input data to the command module and to the computer. Output computer data will control and activate the displays and associated equipment within the command module and instructor - operator consoles.

Peripheral computing equipment will consist of signal conditioning and analog equipment. The analog computer, along with a supporting digital computer will be provided to simulate attitude characteristics during re-entry trajectory. Analog equipment or high resolution digital servo equipment will simulate flight parameters and provide control signals for the visual simulation displays. Flight parameters will include simulated command module weight off-loading, reaction jet malfunction, center of gravity change, moments of inertia, acceleration, velocity, and attitude with respect to the re-entry frame of reference. Computers will perform real time solutions of all equations necessary to represent the dynamic behavior of the re-entry phase. Computer flexibility will be sufficient to absorb simulation changes and incorporate adequate ranges without component modification.

3.1.3.3.6 Air Conditioning Equipment

The simulated command module design will provide for adequate location and positioning of equipment and component assemblies, whose operation involves high heat release, to prevent excessive temperatures within their immediate area. Where high heating is anticipated, forced ventilation to increase heat dissipation will be provided.

The air conditioning system will be capable of providing pre-cooling of the command module and crew at the simulated initial flight phase just prior to service module and command module separation. Due to the extreme high temperatures experienced externally during a portion of the re-entry flight, the air conditioning system will provide the anticipated temperature range and environment within the simulated command module during this problem phase.

The air conditioning system will also provide for the ambient temperature and humidity range and control of the complete training area external to the command module. This area includes the operators consoles, computers and pheripheral equipment.

3.1.3.3.7 Power Equipment

Power generation, distribution and control equipment will be provided as required.

3.1.4 Earth Orbital Trainer (T14-860005)

3.1.4.1 Description

The Earth Orbital Trainer will provide integrated crew training in all phases of the earth orbital mission, (which do not include the Space Laboratory as a part of the mission complex), including earth pre-launch, launch, and orbit phases with launch escape capability. Visual simulation will be provided for launch and orbit. The trainer will be capable of real time sequencing of the complete earth orbital mission and will reflect the high reliability requirements specified for the Apollo spacecraft. The trainer will include simulation of the Mission Control Center and simulated monitoring and tracking sites in order that all phases of an earth orbital mission may be included in the training program. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.1.4.2 Performance Capabilities

The Earth Orbital Trainer will reflect and realistically duplicate spacecraft system performance by utilization of actual systems and components, modified as required for training purposes, or by simulation techniques where degradation of system performance is not compromised. The spacecraft systems represented in the trainer will include, but is not limited to the following major systems:

Navigation and Guidance

Stabilization and Control

Propulsion

Reaction Control

Launch Escape

Environmental Control

Electrical Power

Communications

Instrumentation

Simulation of the Ground Operational Support System (GOSS), Deep Space Instrumentation Facility (DSIF), communications and data link networks will be accomplished by the equipment incorporated in the instructor - operator station(s), for simulation of the Mission Control Center and remote tracking and monitoring sites. The trainer will be capable of providing inflight maintenance training in detection, isolation, and replacement (or alternate mode selection) of malfunctional items.

3.1.4.3 General Equipment Requirements

Complete and effective simulation of the total mission complex programmed for the Apollo spacecraft will require that the Earth Orbital Trainer have the following minimum major assemblies.

3.1.4.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the internal arrangement of the actual command module with respect to size, shape, and equipment location. External configuration will be duplicated only to the extent required for training. Entrance to the simulated command module will be similar to the actual module.

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All controls and displays will be physically and operationally representative of the controls and displays in the actual module. Sounds and vibrations which are conspicuous in the actual module will be simulated with respect to frequency and amplitude.

3.1.4.3.2 Instructor - Operator Station(s)

An integrated arrangement of consoles will be provided for the instructor - operator station(s). The consoles will consist of sufficient controls, displays, and repeater indicators to effectively monitor the overall training program. Repeater indicators will be identical to those in the simulated command module. Provisions will be made for introducing malfunctions and failures. Realistic indications of malfunctions and emergency situations will be presented. Recording and scoring equipment capable of operating at scales and ranges compatible with spacecraft capabilities will be provided. Included will be intercommunication facilities and adequate work areas.

3.1.4.3.3 Visual Simulation Equipment

Visual simulation equipment will provide all visual presentation to the crew members during launch and earth orbital simulated missions. The programmed control of the visual simulation equipment will originate from a real time solution of the spacecraft flight problems. The visual simulation equipment will be analog or high resolution digital servo-mechanisms driven by the digital computer system. The equipment will provide high resolution terrain simulation for the launch phase and a scaled model(s) of the earth for the orbital phase. Provisions will be included for illumination control of the earth model to present a realistic transition from day to night light conditions during the simulated orbit. The earth model simulation will permit variation in the apparent size and detail resolution corresponding to the simulated altitude of the spacecraft. Provisions will be included for lateral translation of the earth model simulation will permit variation in the apparent size and detail resolution corresponding to the simulated altitude of the spacecraft. Provisions will be included for lateral translation of the earth model in order that horizon viewing may be simulated. The visual simulation equipment will include a celestial display for star sighting and navigation corrections during the orbital phase. Simulation of sun light ingress (solar shafting) will be incorporated as part of the visual simulation equipment and will be controlled as a function of simulated spacecraft attitude and earth-orbit position with respect to day or night visual simulation. Color rendition of the earth-terrain simulation will be realistic and based on best obtainable data of color absorption/reflection effects of the atmosphere from launch to orbit altitudes. The visual display system will provide coordinated viewing from the windows and periscope in a manner that will permit realistic representation simultaneously from all viewing apertures. Transmission of visual information from the visual simulation equipment to the crew member observation facilities will be by light-optical techniques or approved equivalent. Transition from one visual display

[redacted]

complex (for example from launch to orbit display), will be obtained with a minimum of crew member detection of the transition. Smooth transitions from one display generation technique to another technique will be accomplished automatically as a function of altitude and/or attitude position of the spacecraft.

3.1.4.3.4 Computers and Peripheral Equipment

Analog and digital computers including analog-to-digital and digital-to-analog conversion equipment will be provided. The digital computing equipment will accept program control routine and subroutine functions and will serve as the heart of the computer complex. Peripheral computing equipment will consist primarily of analog equipment. Analog equipment (or high resolution digital servo-equipment) will simulate the spacecraft flight parameters. This will include spacecraft configuration as related to weight, moments of inertia, acceleration and velocities. Step function and logical controls will utilize digital computer circuitry for functional responses. Utilization of redundant equipments may be required to maintain system accuracies and performance for the time periods representative of the Apollo earth orbital missions. The computers will perform real time solutions of all equations necessary to represent the dynamic behavior of the applicable spacecraft systems. Output data from the computers will actuate the displays and associated equipments. Computer flexibility will be sufficient to absorb changes in simulation (required by spacecraft system modification), and incorporating of adequate ranges without physical modification of computing components.

3.1.4.3.5 Air Conditioning Equipment

The trainer design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates so as to prevent excessive temperatures in their immediate environment. Normal convection will affect the dissipation of heat generated by electronic components. Forced ventilation will be installed where rates of heat dissipation are too high to warrant reliance upon normal convection for cooling. The air conditioning equipment will also provide ambient temperature control of the training areas.

3.1.4.3.6 Power Equipment

Power generation, distribution and control equipment will be provided as required.

3.1.5 Midcourse Correction Trainer (T14-860006)

3.1.5.1 Description

The Midcourse Correction Trainer will provide integrated crew training in all phases of the midcourse situation including, but not limited to, injection into trans-lunar/trans-earth trajectory from parking orbit, ejection from trans-lunar/trans-earth trajectory into parking orbit, and midcourse velocity and trajectory error computation and correction.

The trainer will include visual simulation of the earth-moon-sun situation and an astral display. The visual simulation will be provided in such a way that direct viewing, periscope viewing and astro-sextant sightings may be accomplished with sufficient accuracy to permit their utilization in navigation and velocity measurements. The trainer will include capability for continuous computation of simulated spacecraft position. The trainer will provide a realistic representation of all equipment in the command module which is used either in normal operation or in emergency conditions during the midcourse phase of lunar mission (guidance, navigation, control and communications systems only). The trainer will be capable of real time and accelerated time sequencing of the midcourse phase of lunar missions and will reflect the high reliability requirements specified for the Apollo spacecraft.

All instruments displayed will be computer driven with dynamic responses and accuracies typical of the actual spacecraft instruments. All active controls will be typical of those controls in the actual spacecraft with respect to relative position, appear-ance, and force required for their operation. Provisions will be incorporated in the trainer for injection of malfunctions and transient disturbances characteristic of equipment responses under similar conditions in the actual spacecraft. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.1.5.2 Performance Capability

The Midcourse Correction Trainer will simulate the performance of the actual spacecraft during the midcourse phases of a lunar mission by means of instrument and computer responses. The attitude and spatial position of the spacecraft will be continuously computed as a function of the control functions of the spacecraft and the time-velocity-direction factor of spacecraft spatial translation. The visual presentation of the earth-moon-sun situation and stellar display will be controlled by the attitude and spatial position computers in such a way that the presentation will provide a realistic visual relationship of sufficient accuracy to permit position and velocity computations from the observed relationship. Simulation of DSIF data will be provided to permit comparison of data with observed data by the trainees. The Midcourse Correction Trainer will reflect and realistically duplicate spacecraft systems performance by utilization of actual systems and components, modified as required for training purposes, or by simulation techniques where degradation of the system performance is not compromised.

The spacecraft systems represented in the trainer will include, but are not limited to, the following major systems (only those sections of systems used during parking orbits and earth-moon trajectories need be operationsl):

Navigation and Guidance

Stabilization and Control

Propulsion

Reaction Control

Electrical Power

Communications

Instrumentation

Simulation of the Ground Operational Support System (GOSS), Deep Space Instrumentation Facility (DSIF), communication and data link networks will be accomplished by equipment incorporated in the instructor - operator station(s) for simulation of the Mission Control Center and remote tracking and monitoring sites. The trainer will be capable of providing inflight maintenance training in detection, isolation, and replacement (or alternate mode selection) of malfunctioned items.

3.1.5.3 General Equipment Requirements

Complete and effective simulation of the midcourse situation programmed for the Apollo spacecraft will require that the Midcourse Correction Trainer have the following minimum major assemblies.

3.1.5.3.1 Simulated Command Module

The simulated command module will be an authentic reproduction of the interior of the actual command module with respect to those systems and work stations involved in the midcourse correction procedures. Instrument panels not utilized in the systems involved need not be operational, but will be realistically represented. External configuration of the trainer will duplicate the external configuration of the actual command module only to the extent necessary to provide realistic training procedures. All operational controls and displays will be physically and operationally representative of the controls and displays in the actual command module. Sounds and vibrations which are conspicuous in the actual command module during the midcourse phase will be simulated with respect to frequency and amplitudes.

3.1.5.3.2 Instructor-Operator Station(s)

An integrated arrangement of consoles will be provided for the instructor-operator station(s). The consoles will consist of sufficient controls, displays and repeater indicators to effectively monitor the overall training program. Repeater indicators will be identical to those in the simulated command module. Provisions will be made for introducing malfunctions and errors. Realistic indications of malfunctions and emergency situations will be presented. Recording and scoring equipment capable of operating at scales and ranges compatible with spacecraft capabilities will be provided. Included will be intercommunication facilities and adequate work areas.

[redacted]

3.1.5.3.3 Visual Simulation Equipment

Visual simulation equipment will provide all visual presentations to the crew members applicable to parking orbits and earth-moon trajectories. The programmed midcourse phase of a lunar mission will originate from a real time (with accelerated time capability), solution of the midcourse situation problem. The equipment will be analog or high resolution digital servo-mechanisms driven by the digital computer system. The equipment will provide a celestial display and earth-moon-sun situation display of sufficient accuracy and realism of presentation to permit the use of the astral-sextant for navigational position observations. The visual display system will provide coordinated viewing from the windows, the periscope and the astral-sextant in such a manner that a realistic representation is obtained regardless of the angular displacements of the direction of viewing. The presentation of the earth and moon will be of sufficient resolution that realistic observation of surface detail corresponding to viewing from a minimum distance of 100 nautical miles may be obtained. Color rendition of earth and moon presentation will be based on best obtainable data. Provisions will be made for realistically presenting movement into and out of the fields of view and at the same time simulating the occlusion of the celestial display in the proper relationship to the simulated viewing direction. Provisions will be included for presenting the earth-moon displays in the proper size relationship corresponding to

[redacted]

the computed spatial position of the spacecraft. Provisions will be included for simulation of sunlight ingress through the viewing windows and instruments in such a way that light shafting occurs. Transmission of visual information from the visual display simulation equipment to the crew member observation facilities will be by light optical techniques or approved equivalent. Transition from one scale of presentation to a different scale of presentation will be smooth and with a minimum of crew member detection.

3.1.5.3.4 Computers and Peripheral Equipment

Analog and digital computers including analog-to-digital and digital-to-analog conversion equipment will be provided. The digital computing equipment will accept program control routine and sub-routine functions and will serve as the master control of the computer complex. Peripheral computing equipment will consist primarily of signal conditioning and analog equipment. Analog equipment (or high resolution digital servo equipment) will simulate spacecraft flight parameters and provide the control signals for the visual simulation displays. Flight parameters will include spacecraft configurations related to weight, moments of inertia, acceleration, velocities and spacecraft attitude with respect to the midcourse situation frame of reference. Step function and logical controls will utilize digital computer circuitry for functional responses. Utilization of redundant equipments may be required to maintain system accuracies and performance for the time periods representative of the Apollo midcourse phase.

[redacted]

The computers will perform real time (or accelerated time when selected) solution of all equations necessary to represent the dynamic behavior of the applicable spacecraft system. Accelerated time will be used only during training problem sequences not involving sightings or control manipulation by the crew member trainees. Output data from the computers will actuate the displays and associated equipments. Computer flexibility will be sufficient to absorb changes in simulation (required by spacecraft system modification), and incorporation of adequate ranges without physical modification of computing components.

3.1.5.3.5 Air Conditioning Equipment

The trainer design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates in order to prevent excessive temperatures in their immediate environment. Normal convection will affect the dissipation of heat generated by electronic components. Forced ventilation will be installed where rates of heat dissipation are too high to warrant reliance upon normal convection for cooling. The air conditioning equipment will also provide ambient temperature control for the training areas including the simulated command module and the instructor-operator station(s).

3.1.5.3.6 Power Equipment

Power generation, distribution and control equipment will be provided as part of the trainer as required.

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3.2 Apollo Mission Simulator (T14-860001)

3.2.1 Description

The Apollo Mission Simulator will provide integrated crew training for the pilot commander, co-pilot navigator and systems engineer in all phases of the total mission complex including earth and lunar pre-launch, launch, orbit and landing phases, and trans-lunar, trans-earth midcourse trajectories. The simulator will be capable of real time sequencing of the complete simulated mission and will reflect the high reliability requirements specified for the Apollo spacecraft. Complete visual simulation of the entire mission profile will be provided. The required interface equipment will be provided for inter-connection between the mission simulator and the actual Mission Control Center and remote monitoring sites for complete mission integrated training. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.2.2 Performance Capabilities

The Mission Simulator will reflect and realistically duplicate spacecraft systems performance by utilization of actual systems and components, modified as required for training, or by simulation techniques where systems performance is not degraded. Spacecraft systems performance characteristics applicable for the design of the Mission Simulator are defined below.

[redacted]

3.2.2.1 Command Module Systems

The command module will include all or part of the following major systems:

- Navigation and Guidance
- Stabilization and Control
- Reaction Control
- Launch Escape
- Earth Landing
- Crew
- Environmental Control
- Electrical Power
- Communications and Instrumentation

3.2.2.1.1 Navigation and Guidance System

The major functions of the navigation and guidance system are:

- Primary Inertial Reference
- Acceleration, Velocity and Position determination
- Navigation and Guidance Computation and Prediction
- Abort-Alert Compilation
- Computation for other Spacecraft Systems

The primary attitude reference may be established before lift-off or it may be activated and re-established by electronic and/or optical sighting means during the flight phases. The acceleration, velocity and position function includes the generation and display of spacecraft acceleration, velocity and position data so that these data may be used to manually or automatically control velocity changes required to meet navigational and steering requirements of the Apollo missions. The generation and monitoring of velocity and position data will be backed up and monitored by ground based operations.

The navigation computation and prediction function includes the compilation and monitoring of the moving position of the spacecraft with respect to a number of coordinate axes including those of the earth and moon. The system will also be capable of predicting and displaying future steering and velocity changes required to accomplish the next segment of a particular trajectory. The point-to-point spacecraft compilation and guidance function may be achieved by a series of attitude, acceleration, velocity and present position determinations, by the prediction and display of velocity corrections that are required to navigate to the next trajectory point and then by the generation of the proper thrust and attitude control commands. The abort-alert compilation and display function will include the prediction and the continuous display of data required to accomplish a sudden abort procedure during a critical mission phase.

3.2.2.1.2 <u>Stabilization and Control System</u>

The major functions of the stabilization and control system are:

Secondary Inertial Reference

Attitude Rate

Thrust Vector Control

Manual Control

The secondary inertial reference function provides a short term inertial reference for use in spacecraft control and stabilization. This system functions as a backup mode for the primary inertial reference function of the navigation and guidance system. The system also furnishes an attitude rate function for damping of spacecraft motion. Attitude and attitude rate displays are provided for the flight crew. During injection, midcourse correction and moon/earth landing phases, a thrust vector control function provides for positioning the spacecraft by generating propulsion system commands. A thrust vector display function provides position, thrust-vector and acceleration information to the flight crew. The system also provides a manual control function of the spacecraft during sudden abort conditions and during earth atmospheric entry.

3.2.2.1.3 Reaction Control System

The major functions of the reaction control system are:

Three-axis attitude control function prior to entering the atmosphere.

Roll control function during entry into the atmosphere and earth landing phase.

High altitude atmospheric abort function during the launch phase.

The reaction control system provides the impulse for roll, pitch and yaw after the command module is separated from the service module and before the command module is subjected to the aerodynamic moments of re-entry. This function will rotate the command module to the proper angle of attack for atmospheric entry and then stabilize the angle of attack during the initial buildup of aerodynamic moment.

The atmosphere entry function will include the impulse for an attitude control and attitude stabilization function in roll and also an attitude rate damping function in pitch and yaw. A fixed aerodynamic angle of attack will be obtained by offsetting the center of gravity of the command module. The path of the command module will be controlled aerodynamically by rolling the module lift-force vector about the module velocity vector. The pitch and yaw rate damping function will be used to dampen the oscillations that result from the aerodynamic moment. The atmospheric abort function will include the impulse for roll control for the lift orientation of the launch escape system and a pitch and yaw control function that will resist or minimize command module tumbling during high altitude abort conditions. The reaction control system functions will be controlled by manual electric and automatic electric input signals.

3.2.2.1.4 Launch Escape System

The normal function of the launch escape system will be to provide an abort capability throughout countdown, first-stage boost, and for the first few seconds of second stage firing. After successful ignition of the second-stage booster, the launch escape tower will be separated and laterally translated from the command module and launch vehicle. In the event of an abort operation, the system will provide the impulse to lift the command module from the launch vehicle and laterally translate it to a safe distance. Thrust from the system will result in sufficient altitude to allow safe deployment of the earth landing system. At a given altitude the system will be released from the command module and propelled away prior to the initiation of earth landing operations. Operation of the system will be dictated by crew response and/or by the integrated abort system of the launch vehicle.

3.2.2.1.5 Earth Landing System (Parachute)

The earth landing parachute system will provide spacecraft stabilization and reduce vertical landing velocity from any mission or abort operation. The system will stabilize the command module during the post-entry phase. Stabilization will be accomplished by a drogue parachute during early descent and by landing parachute during the remainder of the descent. The system will provide location and survival

[redacted]

Launch Escape

Environmental Control

Electrical Power

Communications

Instrumentation

Simulation of the Ground Operational Support System (GOSS), Deep Space Instrumentation Facility (DSIF), communications and data link networks will be accomplished by the equipment incorporated in the instructor - operator station(s), for simulation of the Mission Control Center and remote tracking and monitoring sites. The trainer will be capable of providing inflight maintenance training in detection, isolation, and replacement (or alternate mode selection) of malfunctional items.

3.1.4.3 General Equipment Requirements

Complete and effective simulation of the total mission complex programmed for the Apollo spacecraft will require that the Earth Orbital Trainer have the following minimum major assemblies.

3.1.4.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the internal arrangement of the actual command module with respect to size, shape, and equipment location. External configuration will be duplicated only to the extent required for training. Entrance to the simulated command module will be similar to the actual module.

All controls and displays will be physically and operationally representative of the controls and displays in the actual module. Sounds and vibrations which are conspicuous in the actual module will be simulated with respect to frequency and amplitude.

3.1.4.3.2 Instructor - Operator Station(s)

An integrated arrangement of consoles will be provided for the instructor - operator station(s). The consoles will consist of sufficient controls, displays, and repeater indicators to effectively monitor the overall training program. Repeater indicators will be identical to those in the simulated command module. Provisions will be made for introducing malfunctions and failures. Realistic indications of malfunctions and emergency situations will be presented. Recording and scoring equipment capable of operating at scales and ranges compatible with spacecraft capabilities will be provided. Included will be intercommunication facilities and adequate work areas.

3.1.4.3.3 Visual Simulation Equipment

Visual simulation equipment will provide all visual presentation to the crew members during launch and earth orbital simulated missions. The programmed control of the visual simulation equipment will originate from a real time solution of the spacecraft flight problems. The visual simulation equipment will be analog or high resolution digital servo-mechanisms driven by the digital computer system. The equipment will provide high resolution terrain

[redacted]

simulation for the launch phase and a scaled model(s) of the earth for the orbital phase. Provisions will be included for illumination control of the earth model to present a realistic transition from day to night light conditions during the simulated orbit. The earth model simulation will permit variation in the apparent size and detail resolution corresponding to the simulated altitude of the spacecraft. Provisions will be included for lateral translation of the earth model simulation will permit variation in the apparent size and detail resolution corresponding to the simulated altitude of the spacecraft. Provisions will be included for lateral translation of the earth model in order that horizon viewing may be simulated. The visual simulation equipment will include a celestial display for star sighting and navigation corrections during the orbital phase. Simulation of sun light ingress (solar shafting) will be incorporated as part of the visual simulation equipment and will be controlled as a function of simulated spacecraft attitude and earth-orbit position with respect to day or night visual simulation. Color rendition of the earth-terrain simulation will be realistic and based on best obtainable data of color absorption/reflection effects of the atmosphere from launch to orbit altitudes. The visual display system will provide coordinated viewing from the windows and periscope in a manner that will permit realistic representation simultaneously from all viewing apertures. Transmission of visual information from the visual simulation equipment to the crew member observation facilities will be by light-optical techniques or approved equivalent. Transition from one visual display

[redacted]

complex (for example from launch to orbit display), will be obtained with a minimum of crew member detection of the transition. Smooth transitions from one display generation technique to another technique will be accomplished automatically as a function of altitude and/or attitude position of the spacecraft.

3.1.4.3.4 Computers and Peripheral Equipment

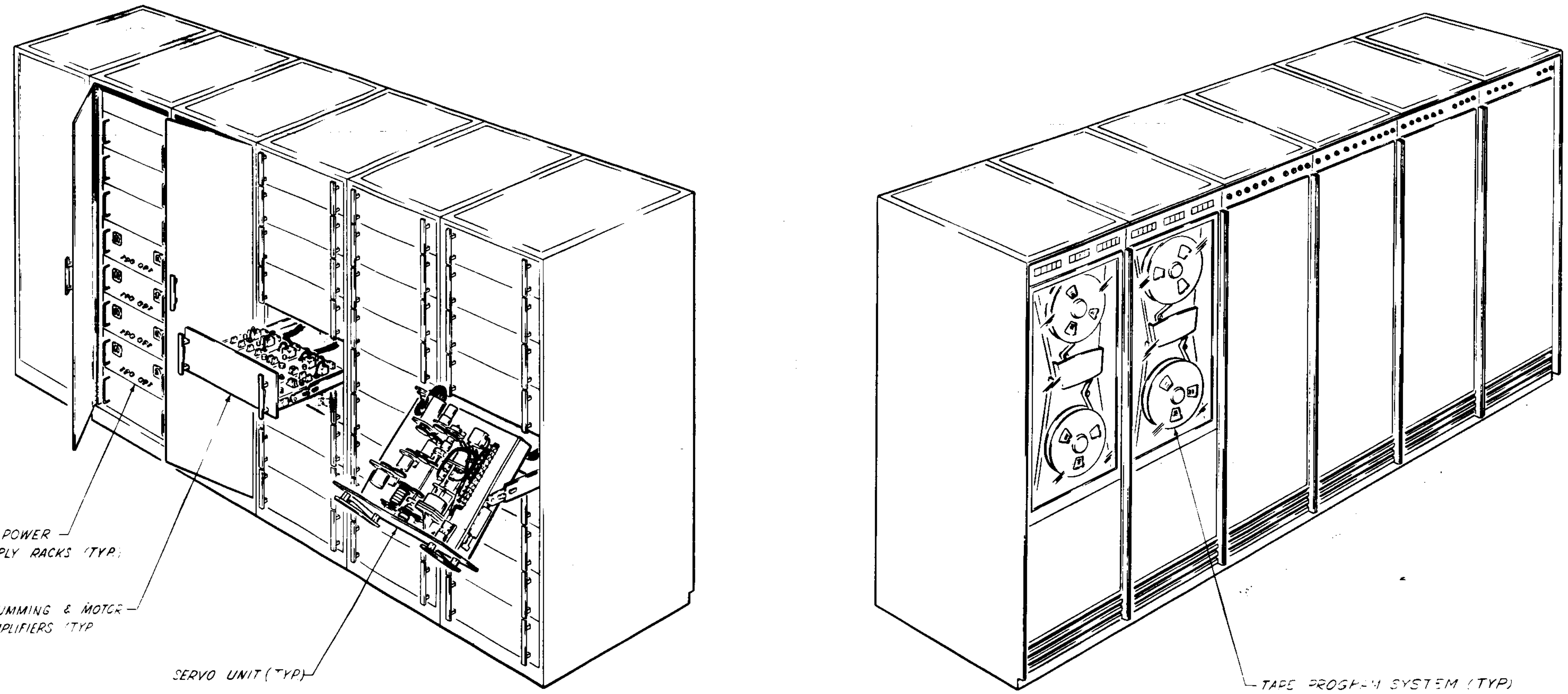
Analog and digital computers including analog-to-digital and digital-to-analog conversion equipment will be provided. The digital computing equipment will accept program control routine and subroutine functions and will serve as the heart of the computer complex. Peripheral computing equipment will consist primarily of analog equipment. Analog equipment (or high resolution digital servo-equipment) will simulate the spacecraft flight parameters. This will include spacecraft configuration as related to weight, moments of inertia, acceleration and velocities. Step function and logical controls will utilize digital computer circuitry for functional responses. Utilization of redundant equipments may be required to maintain system accuracies and performance for the time periods representative of the Apollo earth orbital missions. The computers will perform real time solutions of all equations necessary to represent the dynamic behavior of the applicable spacecraft systems. Output data from the computers will actuate the displays and associated equipments. Computer flexibility will be sufficient to absorb changes in simulation (required by spacecraft system modification), and incorporating of adequate ranges without physical modification of computing components.

3.1.4.3.5 <u>Air Conditioning Equipment</u>

The trainer design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates so as to prevent excessive temperatures in their immediate environment. Normal convection will affect the dissipation of heat generated by electronic components. Forced ventilation will be installed where rates of heat dissipation are too high to warrant reliance upon normal convection for cooling. The air conditioning equipment will also provide ambient temperature control of the training areas.

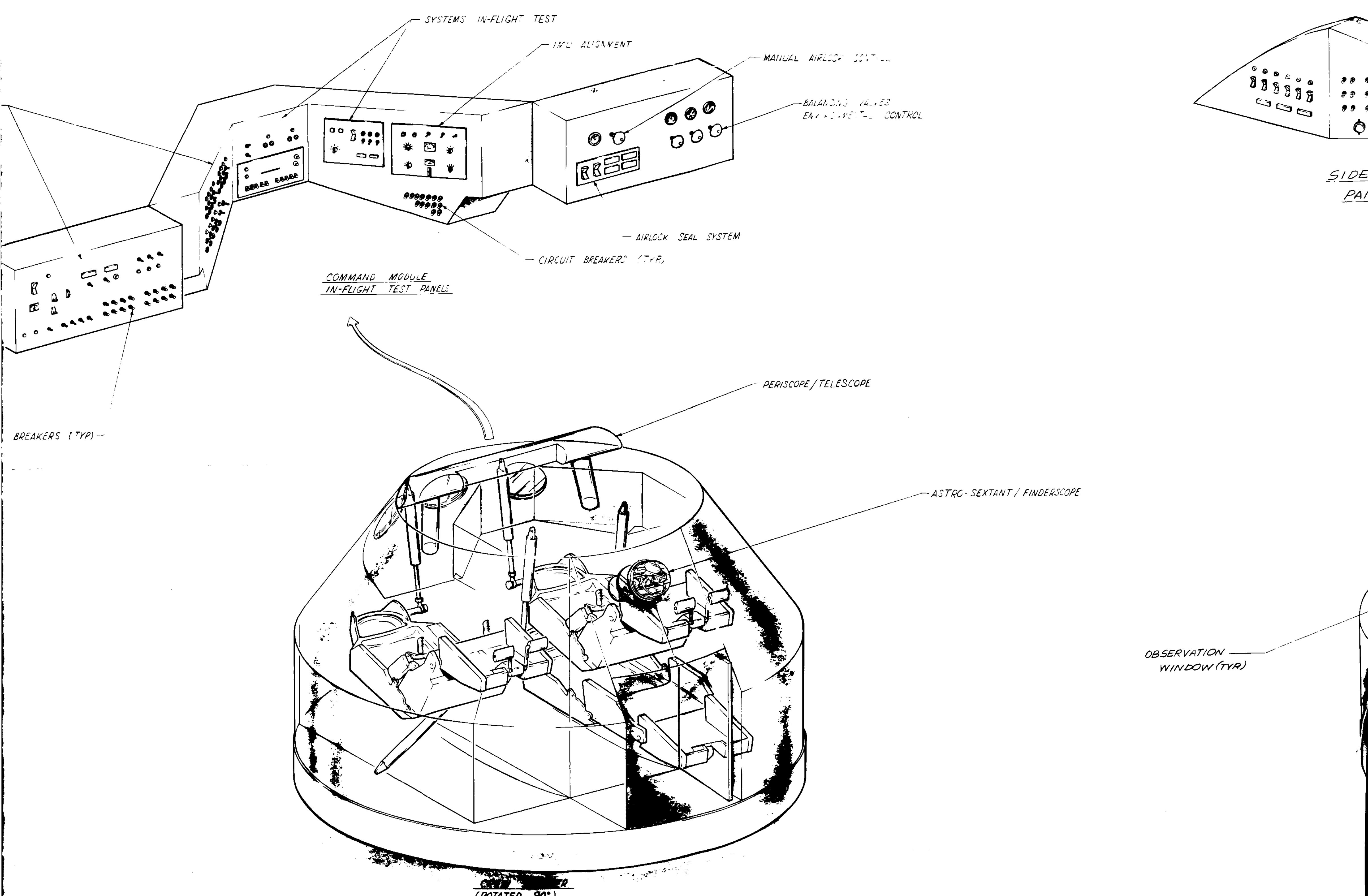
3.1.4.3.6 <u>Power Equipment</u>

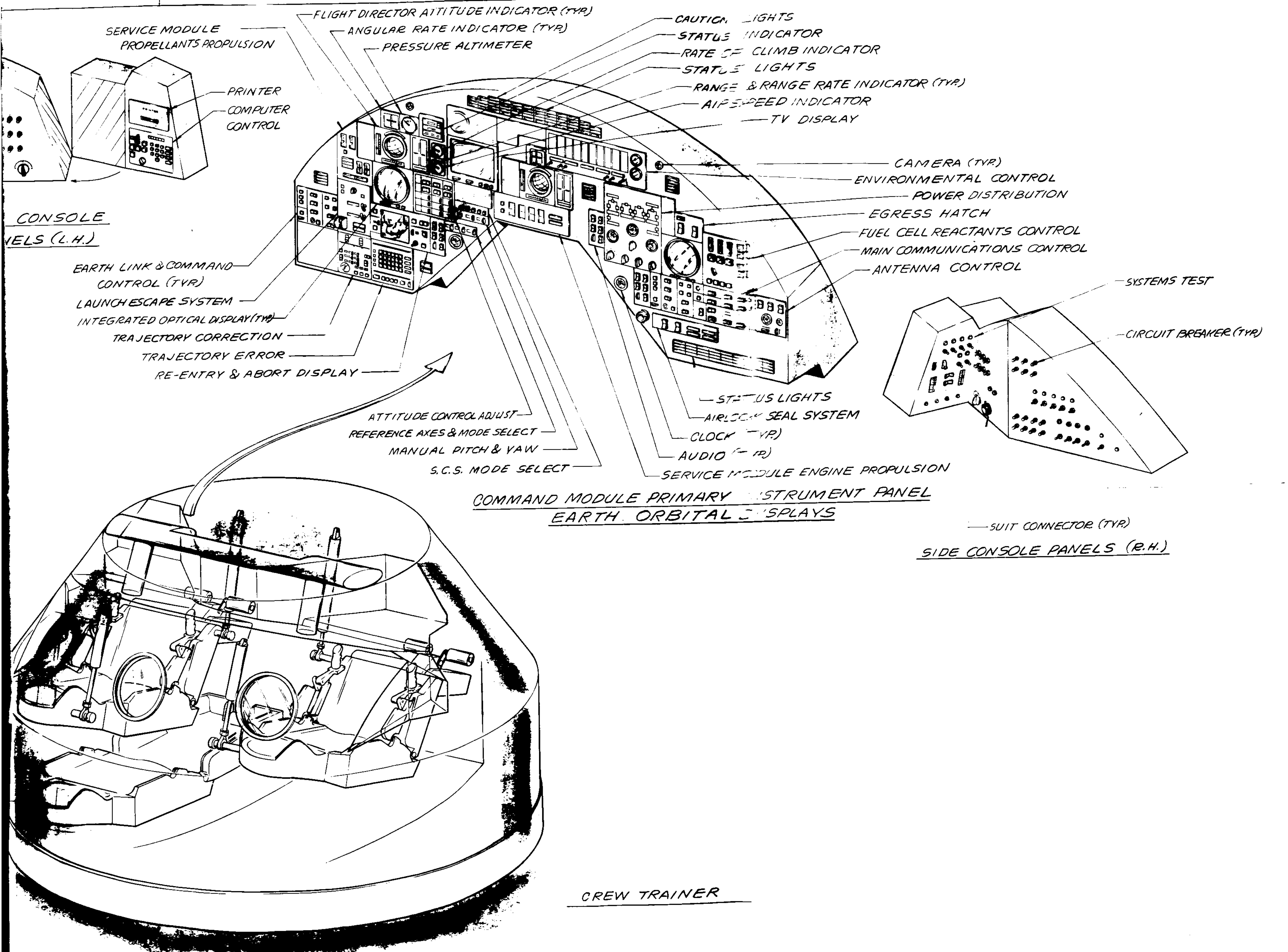
Power generation, distribution and control equipment will be provided as required.



COMPUTER EQUIPMENT CABINETS

ELECTRICAL MODULE
IN-FLIGHT CHECK OUT


SYSTEMS IN-FLIGHT TEST
MANUAL
CONTROL
AIRLOCK SEAL SYSTEM
CIRCUIT BREAKERS (TYP)
COMMAND MODULE
IN-FLIGHT TEST PANELS
BREAKERS (TYP)
PERISCOPE / TELESCOPE
ASTRO-SEXTANT / FINDERSCOPE
OBSERVATION
WINDOW (TYP)
(ROTATED 90°)

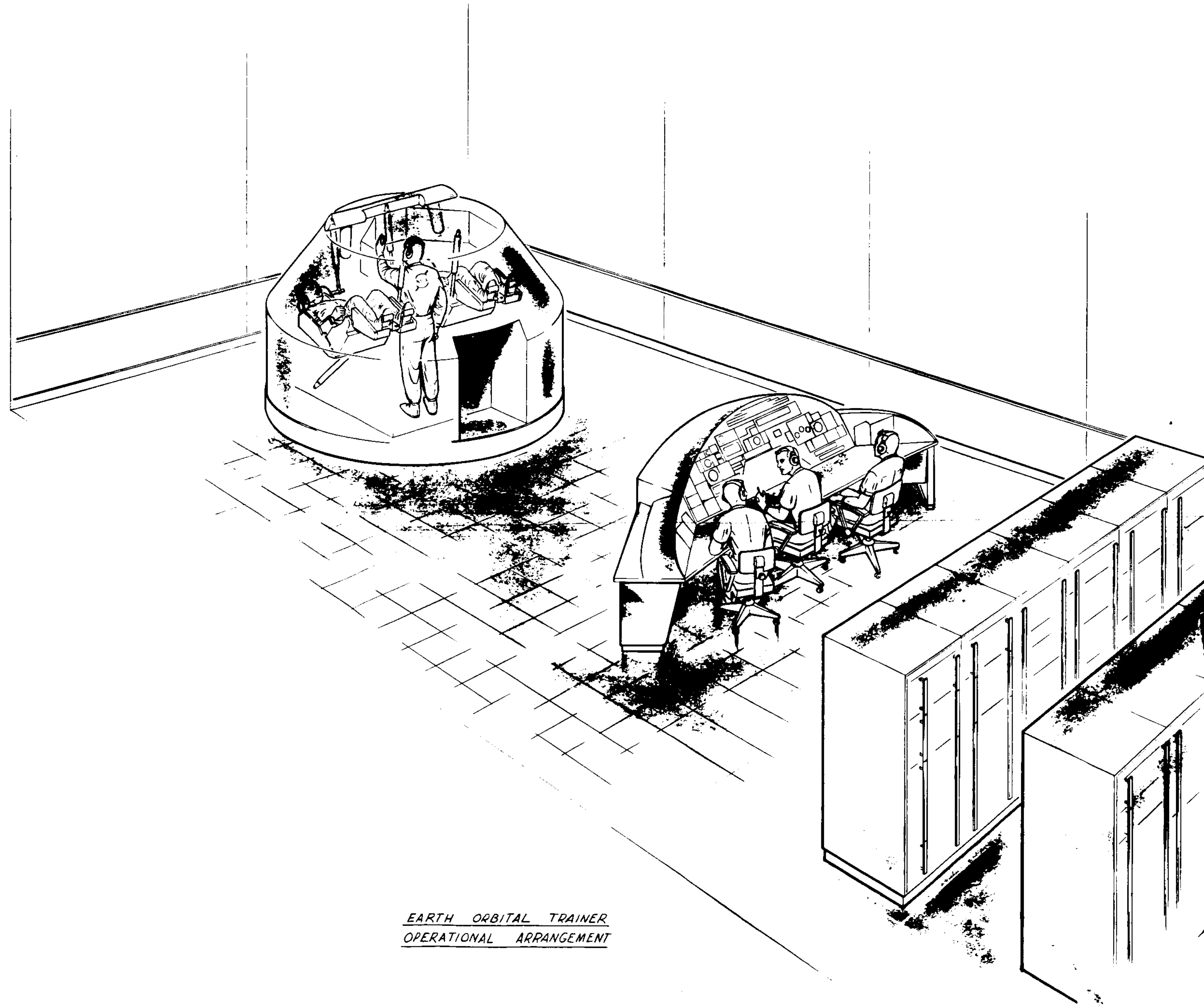


CONSOLE PANELS (L.H.)

COMMAND MODULE PRIMARY INSTRUMENT PANEL
EARTH ORBITAL DISPLAYS

SIDE CONSOLE PANELS (R.H.)

CREW TRAINER



EARTH ORBITAL TRAINER
OPERATIONAL ARRANGEMENT

REVISIONS				
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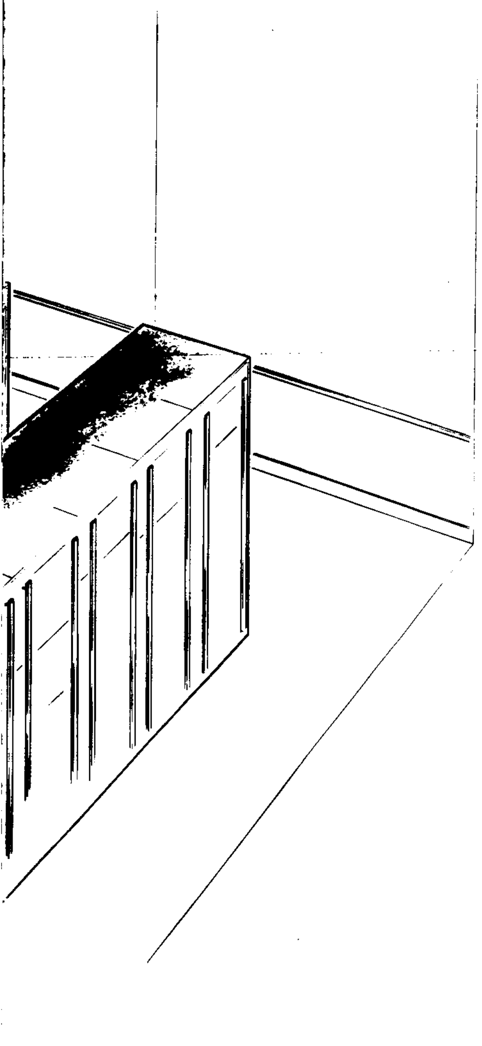

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LIST OF MATERIAL OR PARTS LIST

THIS PRINT REDUCED HALF SIZE

1. VISUAL REFERENCE ATTACHMENT NOT SHOWN

NOTES: UNLESS OTHERWISE SPECIFIED

ITEM	QTY	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
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APPLICATION (USAGE) DATA

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UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:

DECIMALS ANGLES
.XX = ± .03
.XXX = ± .010 ± 30'

HOLES NOTED "DRILL"

.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001

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DR BY [signature] 3-28-66
CHK BY J. Erickson 3-28-66
APPROVED BY [signature]

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER - EARTH ORBITAL.
PART TASK

CODE IDENT NO.	SIZE	
03953	J	T14-860005
SCALE		SHEET

3.1.5 Midcourse Correction Trainer (T14-860006)

3.1.5.1 Description

The Midcourse Correction Trainer will provide integrated crew training in all phases of the midcourse situation including, but not limited to, injection into trans-lunar/trans-earth trajectory from parking orbit, ejection from trans-lunar/trans-earth trajectory into parking orbit, and midcourse velocity and trajectory error computation and correction.

The trainer will include visual simulation of the earth-moon-sun situation and an astral display. The visual simulation will be provided in such a way that direct viewing, periscope viewing and astro-sextant sightings may be accomplished with sufficient accuracy to permit their utilization in navigation and velocity measurements. The trainer will include capability for continuous computation of simulated spacecraft position. The trainer will provide a realistic representation of all equipment in the command module which is used either in normal operation or in emergency conditions during the midcourse phase of lunar mission (guidance, navigation, control and communications systems only). The trainer will be capable of real time and accelerated time sequencing of the midcourse phase of lunar missions and will reflect the high reliability requirements specified for the Apollo spacecraft.

All instruments displayed will be computer driven with dynamic responses and accuracies typical of the actual spacecraft instruments. All active controls will be typical of those controls in the actual spacecraft with respect to relative position, appear-ance, and force required for their operation. Provisions will be incorporated in the trainer for injection of malfunctions and transient disturbances characteristic of equipment responses under similar conditions in the actual spacecraft. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.1.5.2 Performance Capability

The Midcourse Correction Trainer will simulate the performance of the actual spacecraft during the midcourse phases of a lunar mission by means of instrument and computer responses. The attitude and spatial position of the spacecraft will be continuously computed as a function of the control functions of the spacecraft and the time-velocity-direction factor of spacecraft spatial translation. The visual presentation of the earth-moon-sun situation and stellar display will be controlled by the attitude and spatial position computers in such a way that the presentation will provide a realistic visual relationship of sufficient accuracy to permit position and velocity computations from the observed relationship. Simulation of DSIF data will be provided to permit comparison of data with observed data by the trainees. The Midcourse Correction Trainer will reflect and realistically duplicate spacecraft systems performance by utilization of actual systems and components, modified as required for training purposes, or by simulation techniques where degradation of the system performance is not compromised.

The spacecraft systems represented in the trainer will include, but are not limited to, the following major systems (only those sections of systems used during parking orbits and earth-moon trajectories need be operationsl):

Navigation and Guidance

Stabilization and Control

Propulsion

Reaction Control

Electrical Power

Communications

Instrumentation

Simulation of the Ground Operational Support System (GOSS), Deep Space Instrumentation Facility (DSIF), communication and data link networks will be accomplished by equipment incorporated in the instructor - operator station(s) for simulation of the Mission Control Center and remote tracking and monitoring sites. The trainer will be capable of providing inflight maintenance training in detection, isolation, and replacement (or alternate mode selection) of malfunctioned items.

3.1.5.3 General Equipment Requirements

Complete and effective simulation of the midcourse situation programmed for the Apollo spacecraft will require that the Midcourse Correction Trainer have the following minimum major assemblies.

3.1.5.3.1 Simulated Command Module

The simulated command module will be an authentic reproduction of the interior of the actual command module with respect to those systems and work stations involved in the midcourse correction procedures. Instrument panels not utilized in the systems involved need not be operational, but will be realistically represented. External configuration of the trainer will duplicate the external configuration of the actual command module only to the extent necessary to provide realistic training procedures. All operational controls and displays will be physically and operationally representative of the controls and displays in the actual command module. Sounds and vibrations which are conspicuous in the actual command module during the midcourse phase will be simulated with respect to frequency and amplitudes.

3.1.5.3.2 Instructor-Operator Station(s)

An integrated arrangement of consoles will be provided for the instructor-operator station(s). The consoles will consist of sufficient controls, displays and repeater indicators to effectively monitor the overall training program. Repeater indicators will be identical to those in the simulated command module. Provisions will be made for introducing malfunctions and errors. Realistic indications of malfunctions and emergency situations will be presented. Recording and scoring equipment capable of operating at scales and ranges compatible with spacecraft capabilities will be provided. Included will be intercommunication facilities and adequate work areas.

[redacted]

3.1.5.3.3 <u>Visual Simulation Equipment</u>

Visual simulation equipment will provide all visual presentations to the crew members applicable to parking orbits and earth-moon trajectories. The programmed midcourse phase of a lunar mission will originate from a real time (with accelerated time capability), solution of the midcourse situation problem. The equipment will be analog or high resolution digital servo-mechanisms driven by the digital computer system. The equipment will provide a celestial display and earth-moon-sun situation display of sufficient accuracy and realism of presentation to permit the use of the astral-sextant for navigational position observations. The visual display system will provide coordinated viewing from the windows, the periscope and the astral-sextant in such a manner that a realistic representation is obtained regardless of the angular displacements of the direction of viewing. The presentation of the earth and moon will be of sufficient resolution that realistic observation of surface detail corresponding to viewing from a minimum distance of 100 nautical miles may be obtained. Color rendition of earth and moon presentation will be based on best obtainable data. Provisions will be made for realistically presenting movement into and out of the fields of view and at the same time simulating the occlusion of the celestial display in the proper relationship to the simulated viewing direction. Provisions will be included for presenting the earth-moon displays in the proper size relationship corresponding to

[redacted]

the computed spatial position of the spacecraft. Provisions will be included for simulation of sunlight ingress through the viewing windows and instruments in such a way that light shafting occurs. Transmission of visual information from the visual display simulation equipment to the crew member observation facilities will be by light optical techniques or approved equivalent. Transition from one scale of presentation to a different scale of presentation will be smooth and with a minimum of crew member detection.

3.1.5.3.4 Computers and Peripheral Equipment

Analog and digital computers including analog-to-digital and digital-to-analog conversion equipment will be provided. The digital computing equipment will accept program control routine and sub-routine functions and will serve as the master control of the computer complex. Peripheral computing equipment will consist primarily of signal conditioning and analog equipment. Analog equipment (or high resolution digital servo equipment) will simulate spacecraft flight parameters and provide the control signals for the visual simulation displays. Flight parameters will include spacecraft configurations related to weight, moments of inertia, acceleration, velocities and spacecraft attitude with respect to the midcourse situation frame of reference. Step function and logical controls will utilize digital computer circuitry for functional responses. Utilization of redundant equipments may be required to maintain system accuracies and performance for the time periods representative of the Apollo midcourse phase.

The computers will perform real time (or accelerated time when selected) solution of all equations necessary to represent the dynamic behavior of the applicable spacecraft system. Accelerated time will be used only during training problem sequences not involving sightings or control manipulation by the crew member trainees. Output data from the computers will actuate the displays and associated equipments. Computer flexibility will be sufficient to absorb changes in simulation (required by spacecraft system modification), and incorporation of adequate ranges without physical modification of computing components.

3.1.5.3.5 Air Conditioning Equipment

The trainer design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates in order to prevent excessive temperatures in their immediate environment. Normal convection will affect the dissipation of heat generated by electronic components. Forced ventilation will be installed where rates of heat dissipation are too high to warrant reliance upon normal convection for cooling. The air conditioning equipment will also provide ambient temperature control for the training areas including the simulated command module and the instructor-operator station(s).

3.1.5.3.6 Power Equipment

Power generation, distribution and control equipment will be provided as part of the trainer as required.

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3.2 Apollo Mission Simulator (T14-860001)

3.2.1 Description

The Apollo Mission Simulator will provide integrated crew training for the pilot commander, co-pilot navigator and systems engineer in all phases of the total mission complex including earth and lunar pre-launch, launch, orbit and landing phases, and trans-lunar, trans-earth midcourse trajectories. The simulator will be capable of real time sequencing of the complete simulated mission and will reflect the high reliability requirements specified for the Apollo spacecraft. Complete visual simulation of the entire mission profile will be provided. The required interface equipment will be provided for inter-connection between the mission simulator and the actual Mission Control Center and remote monitoring sites for complete mission integrated training. A closed circuit television system will be installed to allow instructor observation of crew member activity during the training period.

3.2.2 Performance Capabilities

The Mission Simulator will reflect and realistically duplicate spacecraft systems performance by utilization of actual systems and components, modified as required for training, or by simulation techniques where systems performance is not degraded. Spacecraft systems performance characteristics applicable for the design of the Mission Simulator are defined below.

[redacted]

3.2.2.1 Command Module Systems

The command module will include all or part of the following major systems:

Navigation and Guidance

Stabilization and Control

Reaction Control

Launch Escape

Earth Landing

Crew

Environmental Control

Electrical Power

Communications and Instrumentation

3.2.2.1.1 Navigation and Guidance System

The major functions of the navigation and guidance system are:

Primary Inertial Reference

Acceleration, Velocity and Position determination

Navigation and Guidance Computation and Prediction

Abort-Alert Compilation

Computation for other Spacecraft Systems

The primary attitude reference may be established before lift-off or it may be activated and re-established by electronic and/or optical sighting means during the flight phases. The acceleration, velocity and position function includes the generation and display of spacecraft acceleration, velocity and position data so that these data may

[redacted]

be used to manually or automatically control velocity changes required to meet navigational and steering requirements of the Apollo missions. The generation and monitoring of velocity and position data will be backed up and monitored by ground based operations.

The navigation computation and prediction function includes the compilation and monitoring of the moving position of the spacecraft with respect to a number of coordinate axes including those of the earth and moon. The system will also be capable of predicting and displaying future steering and velocity changes required to accomplish the next segment of a particular trajectory. The point-to-point spacecraft compilation and guidance function may be achieved by a series of attitude, acceleration, velocity and present position determinations, by the prediction and display of velocity corrections that are required to navigate to the next trajectory point and then by the generation of the proper thrust and attitude control commands. The abort-alert compilation and display function will include the prediction and the continuous display of data required to accomplish a sudden abort procedure during a critical mission phase.

3.2.2.1.2 <u>Stabilization and Control System</u>

The major functions of the stabilization and control system are:

Secondary Inertial Reference

Attitude Rate

Thrust Vector Control

Manual Control

The secondary inertial reference function provides a short term inertial reference for use in spacecraft control and stabilization. This system functions as a backup mode for the primary inertial reference function of the navigation and guidance system. The system also furnishes an attitude rate function for damping of spacecraft motion. Attitude and attitude rate displays are provided for the flight crew. During injection, midcourse correction and moon/earth landing phases, a thrust vector control function provides for positioning the spacecraft by generating propulsion system commands. A thrust vector display function provides position, thrust-vector and acceleration information to the flight crew. The system also provides a manual control function of the spacecraft during sudden abort conditions and during earth atmospheric entry.

3.2.2.1.3 **Reaction Control System**

The major functions of the reaction control system are:

Three-axis attitude control function prior to entering the atmosphere.

Roll control function during entry into the atmosphere and earth landing phase.

High altitude atmospheric abort function during the launch phase.

The reaction control system provides the impulse for roll, pitch and yaw after the command module is separated from the service module and before the command module is subjected to the aerodynamic moments of re-entry. This function will rotate the command module to the proper angle of attack for atmospheric entry and then stabilize the angle of attack during the initial buildup of aerodynamic moment.

The atmosphere entry function will include the impulse for an attitude control and attitude stabilization function in roll and also an attitude rate damping function in pitch and yaw. A fixed aerodynamic angle of attack will be obtained by offsetting the center of gravity of the command module. The path of the command module will be controlled aerodynamically by rolling the module lift-force vector about the module velocity vector. The pitch and yaw rate damping function will be used to dampen the oscillations that result from the aerodynamic moment. The atmospheric abort function will include the impulse for roll control for the lift orientation of the launch escape system and a pitch and yaw control function that will resist or minimize command module tumbling during high altitude abort conditions. The reaction control system functions will be controlled by manual electric and automatic electric input signals.

[redacted]

3.2.2.1.4 Launch Escape System

The normal function of the launch escape system will be to provide an abort capability throughout countdown, first-stage boost, and for the first few seconds of second stage firing. After successful ignition of the second-stage booster, the launch escape tower will be separated and laterally translated from the command module and launch vehicle. In the event of an abort operation, the system will provide the impulse to lift the command module from the launch vehicle and laterally translate it to a safe distance. Thrust from the system will result in sufficient altitude to allow safe deployment of the earth landing system. At a given altitude the system will be released from the command module and propelled away prior to the initiation of earth landing operations. Operation of the system will be dictated by crew response and/or by the integrated abort system of the launch vehicle.

3.2.2.1.5 Earth Landing System (Parachute)

The earth landing parachute system will provide spacecraft stabilization and reduce vertical landing velocity from any mission or abort operation. The system will stabilize the command module during the post-entry phase. Stabilization will be accomplished by a drogue parachute during early descent and by landing parachute during the remainder of the descent. The system will provide location and survival aids necessary for safe and prompt recovery of the spacecraft and crew.

3.2.2.1.6 Earth Landing System (Parawing)

As an alternate to the parachute system the earth landing parawing system will provide spacecraft stabilization, attenuate landing impact, provide recovery aids, and provide a maneuvering capability allowing a choice of landing condition for normal earth landings. The system will stabilize the command module during post-entry descent. This will be accomplished by a drogue parachute during early descent and by the parawing during the remainder of the descent. The system will provide location and survival aids necessary for safe and prompt recovery of the spacecraft and crew.

3.2.2.1.7 Crew System

The crew system will control the overall mission operational phases and support the needs which are peculiar to the presence of human beings aboard the spacecraft. Crew members will have prime and override control of the spacecraft. In the event of equipment malfunction, the crew may repair or replace the equipment, if possible. In an emergency situation, all logical decisions will be made by the crew with the aid of ground stations. The system will attend to the personal hygiene and metabolic needs of the crew members including shaving, bodily cleansing, dental cleansing, deordorizing, eating, drinking, sleeping, elimination of human waste and cleansing of garments. The system will also provide recreation as an aid in maintaining crew morale.

3.2.2.1.8 Environmental Control System

The environmental control system will control the environment in which the flight crew must operate and provide cooling for items of electronic equipment as required. System operation may be automatic with provisions for manual control by the flight crew in the event of an emergency. Regenerative conditioning of the command module atmosphere will include the removal of debris, carbon dioxide and trace contaminants from the air, addition of sufficient oxygen for metabolic needs, addition of sufficient nitrogen for adequate pressure control, and provisions for temperature and relative humidity control. The system will also provide for a water management program including flight crew potable water and a supply of water for sanitation needs.

3.2.2.1.9 Electrical Power System

The major functional divisions of the electrical power system will be power regulation and control, power conversion, electrical energy storage, power distribution and electrical system test. The system will utilize redundant techniques to convert, regulate, control and distribute the required amounts of DC and AC power to the proper spacecraft systems at the proper time. The major system functions will be automatically regulated with provisions for manual selection and control of individual functions and system test functions by the flight crew.

3.2.2.1.10 Communications and Instrumentation Systems

The system will provide the following capabilities:

Convert to electrical signals those physical parameters which must be displayed, recorded or transmitted.

Record on photographic film events occuring within the module as well as on the surface of the moon.

Provide an optical means for observing events external to the spacecraft with magnification as required to give adequate detail.

Convert to electrical signals optical data through the use of a TV camera.

Condition electrical signals to a common level to allow convenient recording and transmission through the telemetry system.

Provide a time reference for all time-dependent spacecraft operations.

Assemble and multiplex in suitable form, for transmission data required on the ground during spacecraft flights.

Store for future readout that data which cannot be transmitted to the ground in real time.

Provide for voice communication between astronauts and provide for the transfer of audio signals to receivers

[redacted]

and transmitters.

Demodulate received R-F signals.

Transmit voice, telemetry and TV signals to ground operational support stations.

Radiate and accumulate electro-magnetic energy.

Receive and respond to interrogating radar signals.

Aid in the location of the spacecraft following re-entry.

Display to the astronaut those functions necessary for control of the communications and instrumentation system.

Display to the astronaut the output of the TV cameras.

Maintain a constant surveillance of onboard spacecraft systems to keep the astronauts advised of their operability.

3.2.2.2 Service Module Systems

The service module will include all or part of the following major spacecraft systems:

Service Propulsion

Reaction Control

Environmental Control

Electrical Power

Communications and instrumentation

3.2.2.2.1 Service Propulsion System

The service propulsion system will provide velocity increments, when required, for designated phases of each mission.

Functional areas include insertion and injection from orbits, orbital maneuvers, midcourse corrections, retro-grade for entry, lunar launch and post-atmospheric abort modes. Ignition of the system motors will be automatic or manual. The crew will prepare the system for ignition, however, actual firing will normally be controlled by automatic signals from the guidance and control system. The crew will be able to control engine operation manually in the event of guidance and control system malfunction.

3.2.2.2.2 Reaction Control System

The major functional divisions of the service module reaction control system are attitude stabilization and control function and a minor velocity increment function. The attitude stabilization and control function will include an attitude control and attitude stabilization function in roll, pitch and yaw of the spacecraft in the earth parking orbit (and also trans-lunar and trans-earth phases except when the service propulsion system or the lunar landing propulsion system is active). The minor velocity increment function will provide minor translational velocity increments to the spacecraft on all flight phases. This function will accomplish minor midcourse corrections, terminal rendezvous and docking, and required accelerations for the service and lunar landing propulsion systems.

[redacted]

3.2.2.2.3 Environmental Control System

The major portion of the excess spacecraft internal heat load will be dissipated by the environmental control system. The system will provide for the storage and regulation of oxygen and nitrogen which may be used by the command module environmental control system in mission phases prior to separation of the service module. The system will also provide a water supply.

3.2.2.2.4 Electrical Power System

The major functional areas of the electrical power system are the generation and distribution of electrical power and the storage, distribution, regulation and control of the reactants utilized by the electrical power supply and the environmental control system.

3.2.2.2.5 Communications and Instrumentation Systems

Equipment to perform the following functions will be included within the service module:

Receive and transmit in phase coherence a signal compatible with the DSIF.

Receive and demodulate voice transmissions from the DSIF.

Receive and transmit ranging code in response to ground originating signals.

Transmit voice, telemetry and TV to the DSIF.

Provide for the direction of received and transmitted

[redacted]

electro-magentic energy.

3.2.2.3 Ground Operational Support System

Simulation of the Ground Operational Support System (GOSS), Deep Space Instrumentation Facility (DSIF), communication and data link networks will be accomplished by functional tie-in between the Mission Simulator, Mission Control Center and remote monitoring sites through the interface equipment. The simulator will be capable of providing inflight maintenance training in detection, isolation and replacement (or alternate mode selection) of malfunctioned items.

3.2.3 General Equipment Requirements

To provide complete and effective simulation of the total mission complex programmed for the Apollo spacecraft, the Mission Simulator will require the following minimum major assemblies.

3.2.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the internal command module with respect to size, shape and equipment location. Some deviation from exact arrangement will be required to compensate for the one g environment of the simulator, however, these deviations will be kept to a minimum consistant with a realistic approach to the problem of crew member orientation and comfort for the prolonged periods of a mission simulation. The external

[redacted]

configuration will be duplicated only to the extent required by the training problem. Ingress and egress to the simulated command module will approximate the arrangement of the actual spacecraft module. All controls and displays in the simulated command module will be representative of the controls and displays in the actual module. Operation of all simulated controls will result in a realistic reaction in the corresponding displays. Actual systems modified as required for training purposes, will be used where maximum effectiveness of the training will result. Simulated systems may be used where no degradation of the training effectiveness may result. Sounds and vibrations which are conspicuous in the actual module will be simulated with respect to frequencies and amplitudes.

3.2.3.2 Instructor - Operator Station (s)

An integrated arrangement of instructor-operator station(s) will be provided as part of the Apollo Mission Simulator complex. A master instructor-operator station will contain the capability for overall mission training problem control and monitor. Instructor-operator stations will be provided which are equivalent in function to each of the major control and monitor consoles of the Mission Control Center. Each console will have repeater indicators identical to the indicators in the simulated command module. The indicators in each station console will be those indicators applicable to the control and monitor requirements of that station. Situations in which more than one station is involved in control and monitor of a particular simulated command module system will require that repeater indicators be provided in each station so involved. Provisions will be incorporated for insertion of malfunctions into the simulated command module systems. Malfunction insertion capability for any system will be restricted to the instructor - operator station(s) primarily concerned with the control and/or monitor of that system and in the master instructor - operator station. The malfunctions, including performance degradation, errors, and failures, shall present a realistic indication of the malfunction and/or emergency situation to the trainees in the simulated command module. Recording and scoring equipment capable of operating at scales and ranges compatible with spacecraft capabilities will be provided. The consoles will contain all controls, displays and indicators necessary to effectively monitor the overall mission training program. Intercommunication facilities and adequate work areas will be included as part of the Apollo Mission Simulator instructor - operator station(s) complex.

3.2.3.3 Visual Simulation Equipment

Visual simulation equipment will provide realistic visual displays to the crew members representing earth and lunar launch, orbit and landings and trans-earth/trans-lunar trajectories. The programmed mission control of the visual simulation equipment will originate from a real time solution of the spacecraft flight problem. The visual simulation equipment will provide a celestial display, earth-moon-sun situation display, and earth/moon launch and landing displays. The visual simulation equipment will provide capability for coordinated simultaneous viewing from windows, periscope and astral -sextant in such a way that the relationship of the display presented to each viewing means will maintain the correct relationship between field of view, angular displacement of the line of sight, and the observable portion of the display. Realism of color will be maintained in the display in accordance with best available data on color attenuation due to atmospheric affects. The display shall be of sufficient accuracy to permit meaningful quantitative observations for navigational purposes. The presentation of the earth and the moon shall be of sufficient resolution that realistic observation of surface detail corresponding to the simulated altitude may be obtained. Launch and landing modes may utilize a representation of specific areas for the lower altitude earth/moon representation with a smooth transition to the wider field of visual coverage required for other phases of the mission. Provisions shall be incorporated for realistically presenting movement into or out of, the fields of view and at the same time simulating the occlusion of the celestial display, the earth, the moon or the sun, as required for accurate presentation of the visual situation. The earth/moon displays shall continuously show the proper size relationship corresponding to the simulated spatial position of the spacecraft. Provisions shall be included for simulation of sunlight ingress through the viewing windows and optical viewing instruments. The shafting effect of sunlight shall be simulated through the viewing windows. Transmission of visual information from the visual display simulation equipment to the crew member observation facilities will be by light-optical techniques or approved equivalent.

3.2.3.4 Computers and Peripheral Equipment

Analog and digital computers including analog-to-digital and digital-to-analog conversion equipment will be provided. The digital computing equipment will accept program control routine and sub-routine functions and will serve as the heart of the computer complex. Peripheral computing equipment will consist primarily of analog equipment. Analog equipment will simulate the spacecraft flight parameters. This will include spacecraft configuration as related to weight, moments of inertia, accelerations and velocities. Step function and logical controls will utilize digital computer circuitry for functional response. Utilization of redundant equipment will be required to maintain systems accuracies for extended time periods representative of the Apollo mission. The computers will perform real time solutions of all equation necessary to represent the dynamic behavior of the applicable spacecraft systems. Output data from the computers will actuate the displays and associated equipments. Computer flexibility will be sufficient to absorb changes in simulation (required by spacecraft system modification), and incorporate adequate ranges without physical modification of computing components.

3.2.3.5 Air Conditioning Equipment

The simulator design will provide for adequate positioning and spacing of components whose operation involves the release of heat at appreciable rates so as to prevent excessive temperatures in their immediate environment. Normal convection will effect the dissipation of heat generated by electronic components. Where the rate of heat dissipation is too high to warrant reliance upon normal convection for cooling, forced ventilation will be installed. The air conditioning equipment will also provide ambient temperature control of the training area.

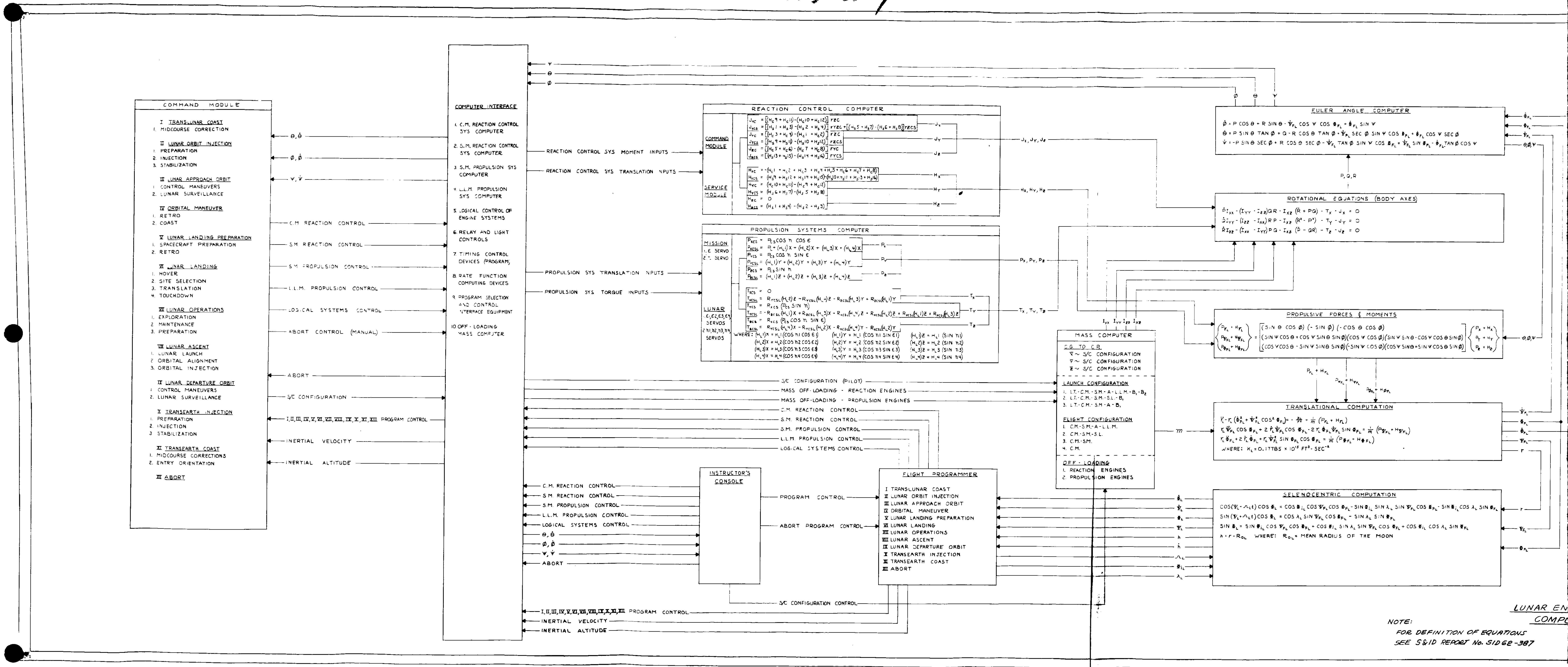
3.2.3.6 Interface Equipment

The required interface equipment will provide interconnection between the simulator and Mission Control Center and remote monitoring sites. Primary control of the simulator will be via the Mission Control Center through the interface equipment with overall management at the instructor-operator station(s).

3.2.3.7 Power Equipment

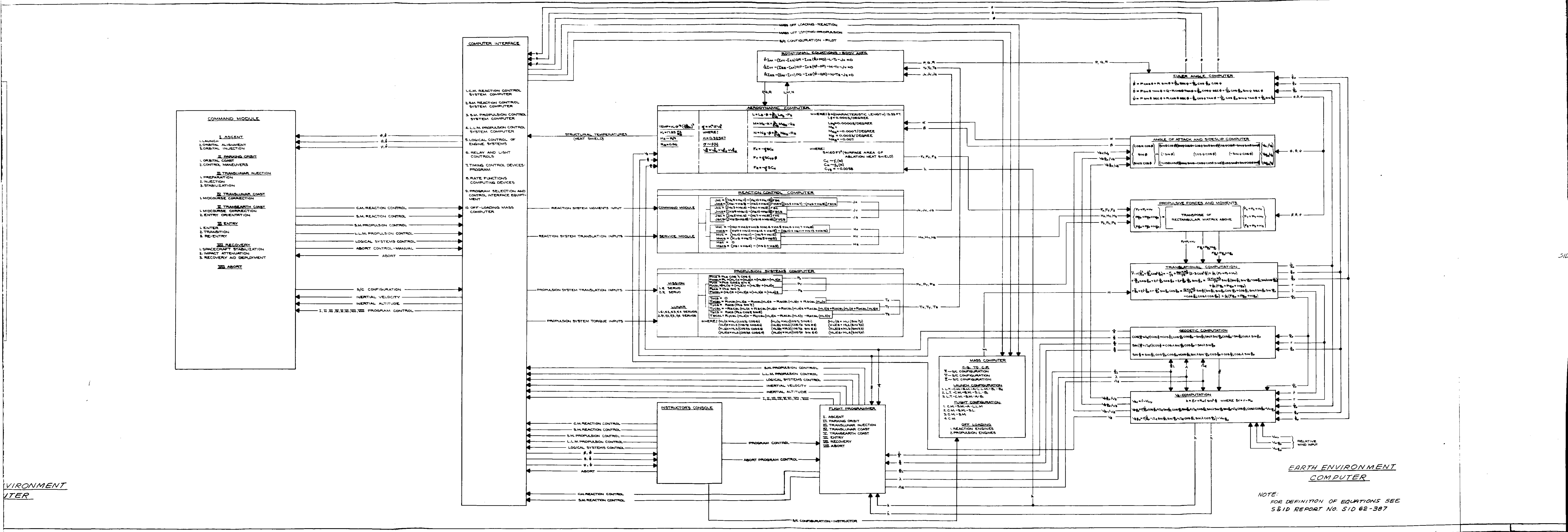
Power generation, distribution and control equipment will be provided as required.

#1 of 4

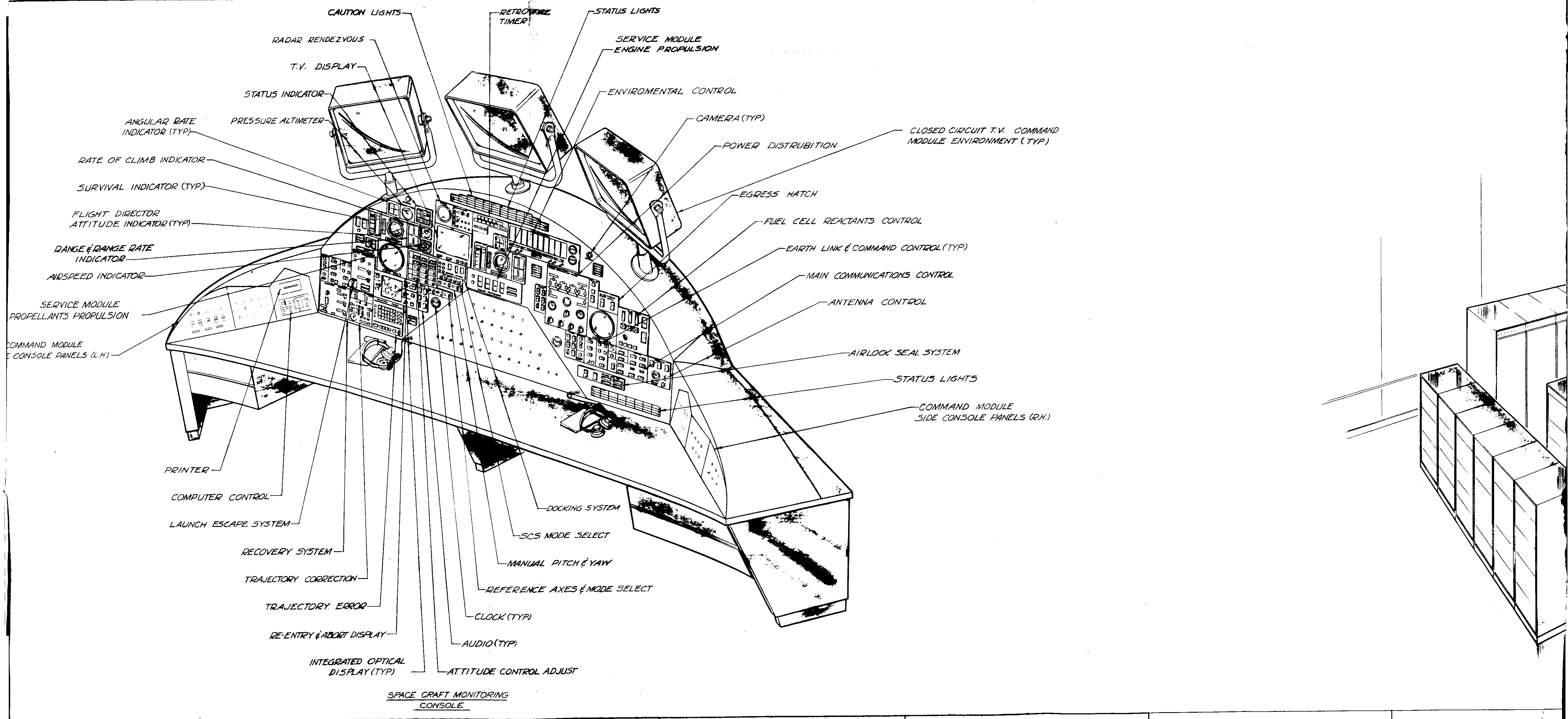


COMMAND MODULE
I TRANSLUNAR COAST
1. MIDCOURSE CORRECTION
II LUNAR ORBIT INJECTION
1. PREPARATION
2. INJECTION
3. STABILIZATION
III LUNAR APPROACH ORBIT
1. CONTROL MANEUVERS
2. LUNAR SURVEILLANCE
IV ORBITAL MANEUVER
1. RETRO
2. COAST
V LUNAR LANDING PREPARATION
1. SPACECRAFT PREPARATION
2. RETRO
VI LUNAR LANDING
1. HOVER
2. SITE SELECTION
3. TRANSLATION
4. TOUCHDOWN
VII LUNAR OPERATIONS
1. EXPLORATION
2. MAINTENANCE
3. PREPARATION
VIII LUNAR ASCENT
1. LUNAR LAUNCH
2. ORBITAL ALIGNMENT
3. ORBITAL INJECTION
IX LUNAR DEPARTURE ORBIT
1. CONTROL MANEUVERS
2. LUNAR SURVEILLANCE
X TRANSEARTH INJECTION
1. PREPARATION
2. INJECTION
3. STABILIZATION
XI TRANSEARTH COAST
1. MIDCOURSE CORRECTIONS
2. ENTRY ORIENTATION
XII ABORT
C.M. REACTION CONTROL
S.M. REACTION CONTROL
S.M. PROPULSION CONTROL
L.L.M. PROPULSION CONTROL
LOGICAL SYSTEMS CONTROL
ABORT CONTROL (MANUAL)
ABORT
S/C CONFIGURATION
I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII PROGRAM CONTROL
INERTIAL VELOCITY
INERTIAL ALTITUDE
COMPUTER INTERFACE
1. C.M. REACTION CONTROL SYS COMPUTER
2. S.M. REACTION CONTROL SYS COMPUTER
3. S.M. PROPULSION SYS COMPUTER
4. L.L.M. PROPULSION SYS COMPUTER
5. LOGICAL CONTROL OF ENGINE SYSTEMS
6. RELAY AND LIGHT CONTROLS
7. TIMING CONTROL DEVICES (PROGRAM)
8. RATE FUNCTION COMPUTING DEVICES
9. PROGRAM SELECTION AND CONTROL INTERFACE EQUIPMENT
10. OFF - LOADING MASS COMPUTER
REACTION CONTROL SYS MOMENT INPUTS
REACTION CONTROL SYS TRANSLATION INPUTS
PROPULSION SYS TRANSLATION INPUTS
PROPULSION SYS TORQUE INPUTS
REACTION CONTROL COMPUTER
COMMAND MODULE
SERVICE MODULE
PROPULSION SYSTEMS COMPUTER
MISSION
LUNAR
SERVOS
S/C CONFIGURATION (PILOT)
MASS OFF-LOADING - REACTION ENGINES
MASS OFF-LOADING - PROPULSION ENGINES
C.M. REACTION CONTROL
S.M. REACTION CONTROL
S.M. PROPULSION CONTROL
L.L.M. PROPULSION CONTROL
LOGICAL SYSTEMS CONTROL
INSTRUCTOR'S CONSOLE
PROGRAM CONTROL
ABORT PROGRAM CONTROL
FLIGHT PROGRAMMER
I TRANSLUNAR COAST
II LUNAR ORBIT INJECTION
III LUNAR APPROACH ORBIT
IV ORBITAL MANEUVER
V LUNAR LANDING PREPARATION
VI LUNAR LANDING
VII LUNAR OPERATIONS
VIII LUNAR ASCENT
IX LUNAR DEPARTURE ORBIT
X TRANSEARTH INJECTION
XI TRANSEARTH COAST
XII ABORT
S/C CONFIGURATION CONTROL
MASS COMPUTER
C.G. TO C.R.
LAUNCH CONFIGURATION
FLIGHT CONFIGURATION
OFF - LOADING
1. REACTION ENGINES
2. PROPULSION ENGINES
EULER ANGLE COMPUTER
ROTATIONAL EQUATIONS (BODY AXES)
PROPULSIVE FORCES & MOMENTS
TRANSLATIONAL COMPUTATION
SELENOCENTRIC COMPUTATION
WHERE: R_{OL} = MEAN RADIUS OF THE MOON
LUNAR EN
COMP
NOTE:
FOR DEFINITION OF EQUATIONS
SEE S&ID REPORT No. SID62-387

\#2 of 4



COMMAND MODULE
I ASCENT
1. LAUNCH
2. ORBITAL ALIGNMENT
3. ORBITAL INJECTION
II PARKING ORBIT
1. ORBITAL COAST
2. CONTROL MANEUVERS
III TRANSLUNAR INJECTION
1. PREPARATION
2. INJECTION
3. STABILIZATION
IV TRANSLUNAR COAST
1. MIDCOURSE CORRECTION
V TRANSEARTH COAST
1. MIDCOURSE CORRECTION
2. ENTRY ORIENTATION
VI ENTRY
1. ENTER
2. TRANSITION
3. RE-ENTRY
VII RECOVERY
1. SPACECRAFT STABILIZATION
2. IMPACT ATTENUATION
3. RECOVERY AID DEPLOYMENT
VIII ABORT
COMPUTER INTERFACE
1. C.M. REACTION CONTROL SYSTEM COMPUTER
2. S.M. REACTION CONTROL SYSTEM COMPUTER
3. S.M. PROPULSION CONTROL SYSTEM COMPUTER
4. L.L.M. PROPULSION CONTROL SYSTEM COMPUTER
5. LOGICAL CONTROL OF ENGINE SYSTEMS
6. RELAY AND LIGHT CONTROLS
7. TIMING CONTROL DEVICES-PROGRAM
8. RATE FUNCTIONS COMPUTING DEVICES
9. PROGRAM SELECTION AND CONTROL INTERFACE EQUIPMENT
10. OFF-LOADING MASS COMPUTER
C.M. REACTION CONTROL
S.M. REACTION CONTROL
S.M. PROPULSION CONTROL
L.L.M. PROPULSION CONTROL
LOGICAL SYSTEMS CONTROL
ABORT CONTROL-MANUAL
ABORT
S/C CONFIGURATION
INERTIAL VELOCITY
INERTIAL ALTITUDE
PROGRAM CONTROL
MASS OFF LOADING-REACTION
MASS OFF LOADING-PROPULSION
S/C CONFIGURATION-PILOT
STRUCTURAL TEMPERATURES (HEAT SHIELD)
REACTION SYSTEM MOMENTS INPUT
REACTION SYSTEM TRANSLATION INPUTS
PROPULSION SYSTEM TRANSLATION INPUTS
PROPULSION SYSTEM TORQUE INPUTS
ROTATIONAL EQUATIONS-BODY AXES
AERODYNAMIC COMPUTER
REACTION CONTROL COMPUTER
COMMAND MODULE
SERVICE MODULE
PROPULSION SYSTEMS COMPUTER
MISSION
LUNAR
EULER ANGLE COMPUTER
ANGLE OF ATTACK AND SIDESLIP COMPUTER
PROPULSIVE FORCES AND MOMENTS
TRANSPOSE OF RECTANGULAR MATRIX ABOVE
TRANSLATIONAL COMPUTATION
GEODETIC COMPUTATION
V_R-COMPUTATION
RELATIVE WIND INPUT
MASS COMPUTER
C.G. TO C.P.
LAUNCH CONFIGURATION
FLIGHT CONFIGURATION
OFF LOADING
1. REACTION ENGINES
2. PROPULSION ENGINES
INSTRUCTOR'S CONSOLE
FLIGHT PROGRAMMER
I ASCENT
II PARKING ORBIT
III TRANSLUNAR INJECTION
IV TRANSLUNAR COAST
V TRANSEARTH COAST
VI ENTRY
VII RECOVERY
VIII ABORT
ABORT PROGRAM CONTROL
S/C CONFIGURATION-INSTRUCTOR
EARTH ENVIRONMENT COMPUTER
NOTE: FOR DEFINITION OF EQUATIONS SEE S&ID REPORT NO. SID 62-387



SPACE CRAFT MONITORING CONSOLE

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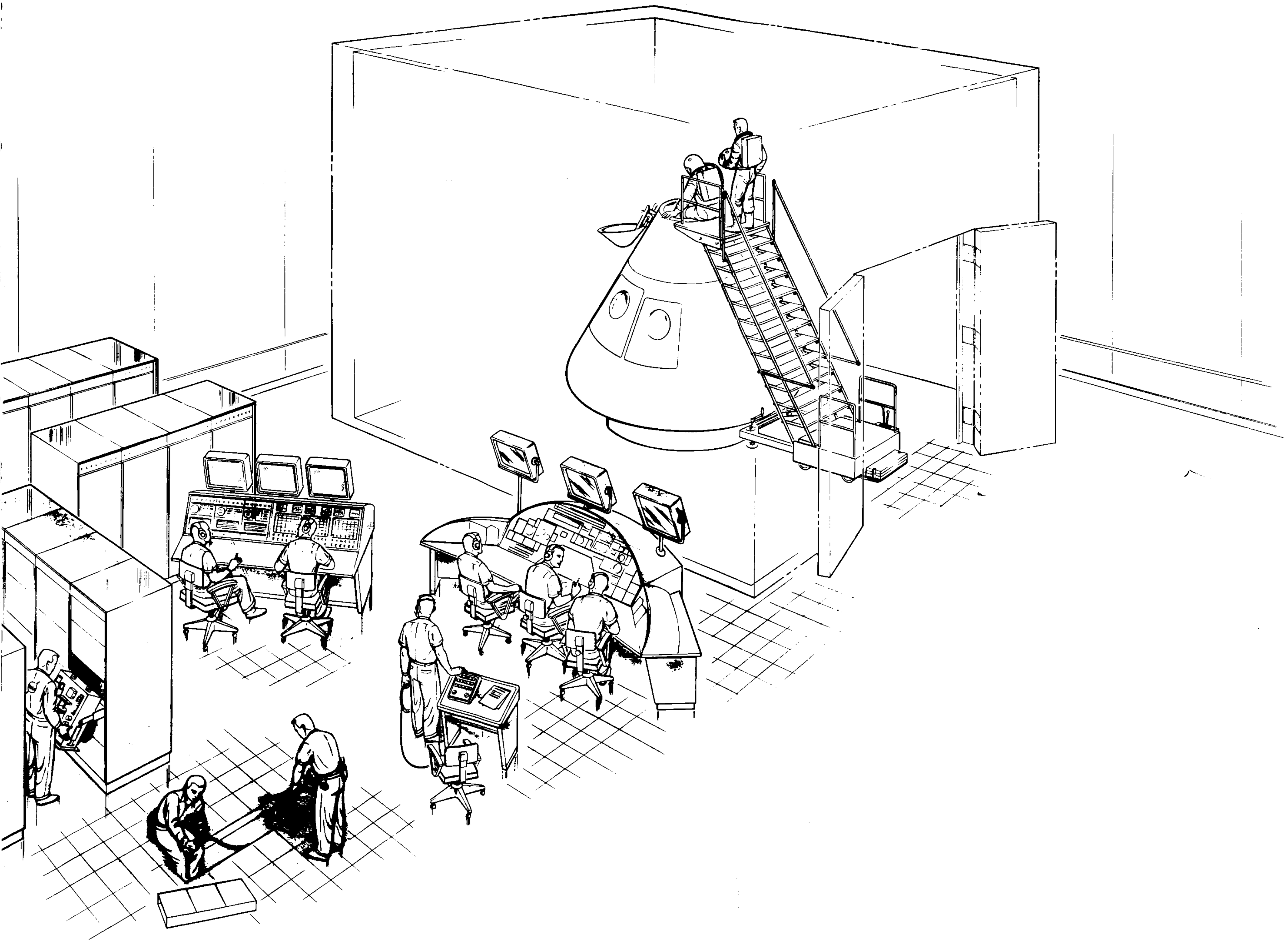

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LIST OF MATERIAL OR PARTS LIST

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HEAT TREAT

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HOLES NOTED "DRILL"
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1.001 THRU 2.000 : +.010 -.001
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CHK BY J Erickson 9-28-62
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TRAINER - MISSION SIMULATOR, COMP. TASK

CODE IDENT NO. 03953 | SIZE J | T14-860001

SCALE | SHEET

3.3 Crew Survival Trainers

The crew survival trainers will be designed to provide crew training in tasks related to command module egress within simulated environments typical of the Apollo mission complex. The training will encompass those tasks within, and external to the simulated command module that are required for the specific environmental situation to be simulated by each trainer. Individual trainer configurations will be dependent upon tasks to be performed and are described in the following paragraphs.

[redacted]

3.3.1 Egress Trainer (T14-860007)

3.3.1.1 Description

The Egress Trainer will provide the training and practice for a three man crew to develop control skills relative to egress procedures upon return to earth from orbital or lunar flight. The trainer will provide simulated situations for normal or emergency egress from the command module after an earth or water landing under a variety of environmental and atmospheric conditions including temperature extremes.

3.3.1.2 Performance Capabilities

The Egress Trainer consisting primarily of a simulated command module, will be capable of egress training under conditions which include:

(a) Unusual attitudes of capsule upon landing in rough terrain, or caused by the possible tumbling of the capsule during an earth landing resulting in a capsule upset.

(b) A water landing in rough seas causing violent capsule rocking resulting in the hampering of normal egress procedures.

(c) A shift in the command module C.G. resulting in the upset of the hydrodynamic stability after water impact.

(d) Land or water landing in all areas from topics to the Artic under extreme atmospheric and environmental situations.

(e) Power failure necessitating the switchover to manual control and operation of the egress hatch system.

(f) Crew incapacitation resulting in the emergency egress by exterior methods.

Only the following control systems are in full or partial operation during the egress operations:

(a) Egress hatch system

(b) Communications system

(c) Electrical power system

To avoid redundancy, only those portions of each system functioning during the egress phase will be considered active and included in the trainer concept. The trainer will duplicate these functions by the utilization of actual system components where practical or modifications when desirable.

3.3.1.2.1 Egress Hatch System

The egress hatch system consists of both a pyrotechnic and manually operated series of clamping devices which surround the hatch and hold it firmly in position over the command module egress opening. The pyrotechnic system involves the use of gas generators which when fired will eject the hatch. The pyrotechnic devices are activated by an arming and firing DC circuit through switches located on the command module instrument panel. The manual operation of the system in an emergency is accomplished through mechanical disconnects.

[redacted]

For the trainer application, the egress hatch system will consist of both an electrical and mechanical system, however, the pyrotechnic devices will be substituted by a solenoid and spring action controlled from the instrument panel by simulated hatch system controls.

3.3.1.2.2 Communications System

The portions of the communications system which function during the egress procedures are as follows:

(a) H.F. voice and beacon

(b) Rescue beacon

(c) V.H.F. voice and data

(d) Personal communications

  (1) Intercom system between crew members consisting of a belt pack in the space suit containing a transmitter and receiver.

Communications controls are located on the command module instrument panel and consist of "ON" "OFF" switches and mode changes. For the trainer application only the personal communications sub-system will be utilized. Intercoms will function between crew in space suits and instructor or monitoring group for the recording and evaluation of crew activities.

3.3.1.2.3 Electrical Power System

The portion of the electrical power system utilized during egress is a post-landing 100W battery with a three day life expectancy. This power supply will provide power for the operation of the communications system and the environmental control system.

3.3.1.2.4 Mechanical System

The mechanical system will include only that portion which is directly related to the operation of hatches, airlock and survival and recovery aids deployment.

3.3.1.3 General Requirements

To provide for the complete and effective crew training, the egress trainer will require the following major assemblies.

3.3.1.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the actual spacecraft with regard to shape, size, weight and hatch and airlock configuration. The interior configuration will include all actual, modified or mocked-up controls, equipment, displays, etc. All equipment and controls pertinent to the egress problem will be actual flight units where practical or operational modifications. Such other equipment not directly associated with egress will be mocked-up actual size and installed in the correct location. Hatches, windows, airlock and such mechanical or electrical devices necessary for complete simulation of hatch and airlock removal will be duplicated and operable. The simulated command module will have hydrodynamic characteristics and will be mobile or have supporting structure and capabilities to the extent of being transported to various land or water locations to simulate egress training under a maximum variety of environmental and atmospheric conditions. A form of protection will be included to protect the simulator during transport and handling on land or water.

3.3.1.3.2 Hatch Configuration

The hatch configuration consists of three hatches located on the command module side wall in close proximity to each other. The center hatch, approximately 34" high by 28" wide at the base, is normally used for ingress and egress. The two other hatches located one on each side of the center hatch are both approximately 30" high by 27" wide at the base. A 15" diameter viewing window is part of each hatch. Under actual flight conditions the center hatch is considered the normal for ingress and egress. The smaller right and left hatches are for emergency use only. All three hatches are capable of being blown free from the command module body by pyrotechnic devices through an arming and firing circuit, or being ejected by manually operated mechanical latches. For the trainer, no pyrotechnic devices will be incorporated. The hatch removal in this instance will be accomplished by solenoid or spring actuated latch mechanisms. A hinge assembly to keep the hatch attached to the simulated command module for further use will be provided. The manual mechanical method of hatch removal, with reference to operating levers, handwheels, etc., will be identical to actual spacecraft configuration, with the exception of the hinging arrangement or similar structure to prevent loss or damage. The main, or center, hatch is capable of exterior manual removal.

3.3.1.3.3 Air Lock

The command module air lock is used as an emergency egress hatch, and is normally opened and controlled manually through a series of mechanical latching mechanisms. In the simulator the air lock and control devices will be reproduced to actual spacecraft configuration. The air lock in an emergency will be capable of being opened from outside the trainer.

3.3.1.3.4 Recovery and Survival Equipment

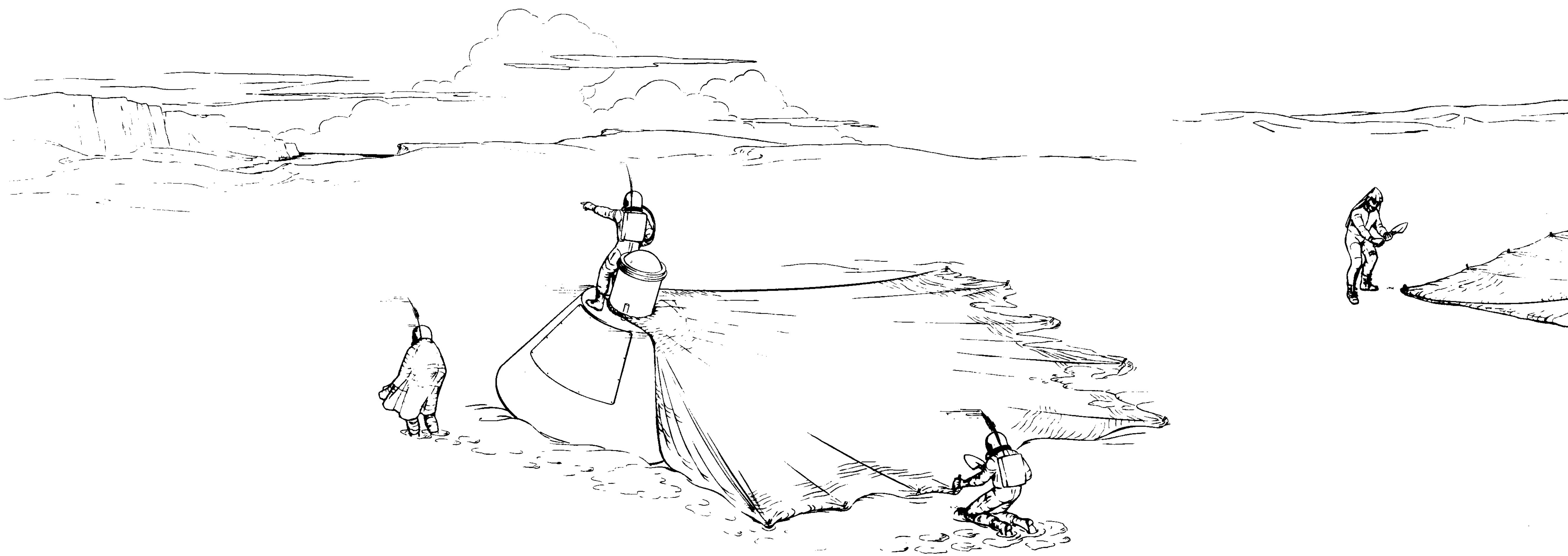
The recovery and survival equipment normally a part of the spacecraft at the egress phase, or activated during the landing procedure, will be stowed in the simulator either as actual equipment or mock-ups. The recovery and location aids equipment will consist of radio beacons, sofar bomb, dye-markers, flares and light beacon. The survival equipment will consist of space suits, food, water, fishing gear, rafts, firearms, tools, ropes and shelters. The recovery equipment is deployed by electrical methods activated by switches located on the command module instrument panel. Survival equipment is manually deployed. Space suit environment is controlled and capable of operation for a twenty-four hour period by the post landing battery power supply in the command module.

3.3.1.3.5 Power Equipment

The power equipment normally in operation during the landing and egress phase consists of a 100W, 28 VDC post landing battery. For trainer use a conversion power supply will be incorporated to fulfill all electrical requirements for communications equipment, instrument panel displays, switches and electrical operating devices, lighting, environmental equipment and control and monitor console equipment.

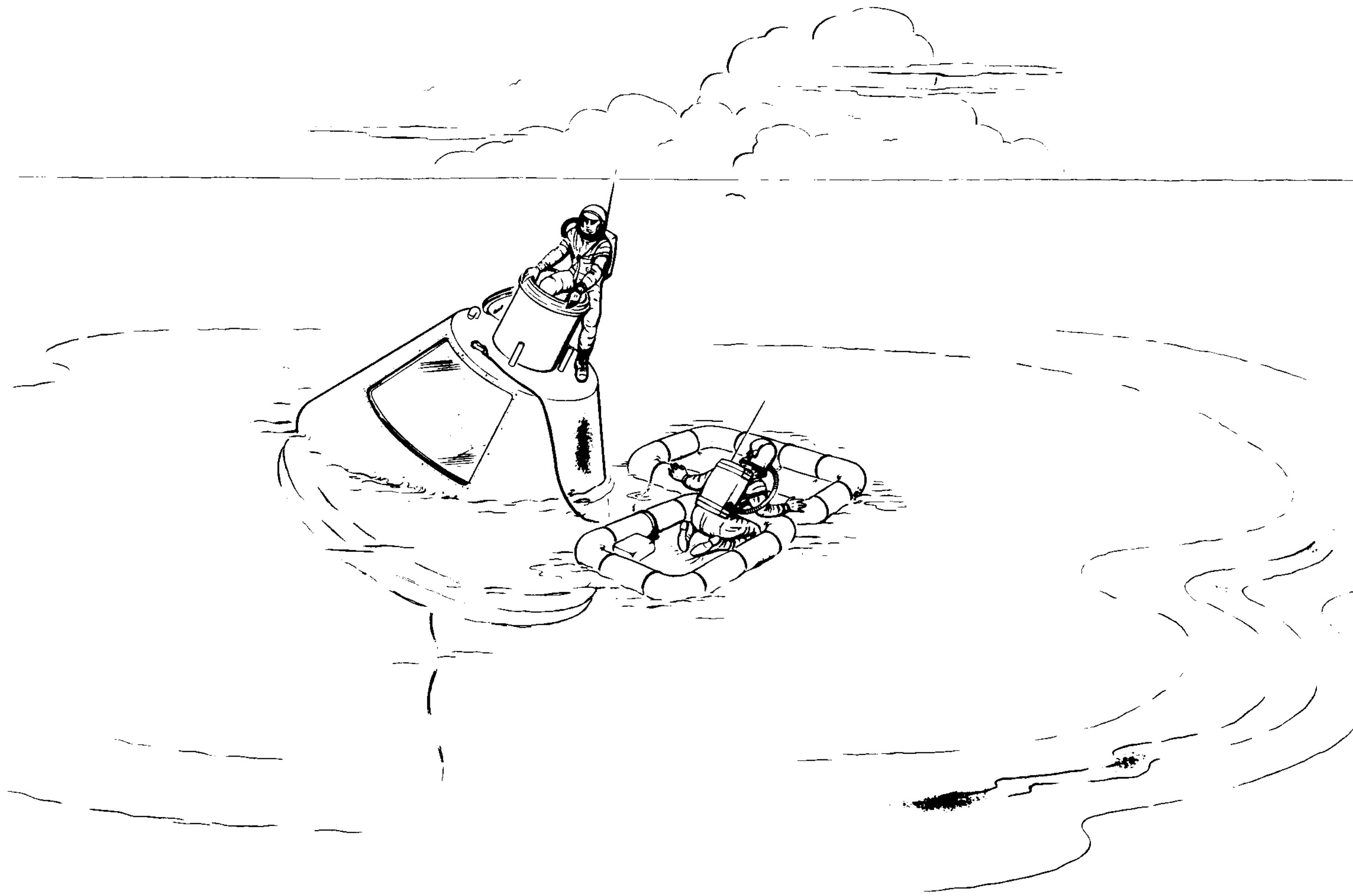
3.3.1.3.6 Monitor Console Panel

A monitoring console will be supplied to monitor, record and evaluate the crew's actions during normal and emergency egress. Controls and displays in operation during landing and egress, as part of the command module instrument panel will be duplicated on the monitor panel. Communications between crew and instructor will be supplied.

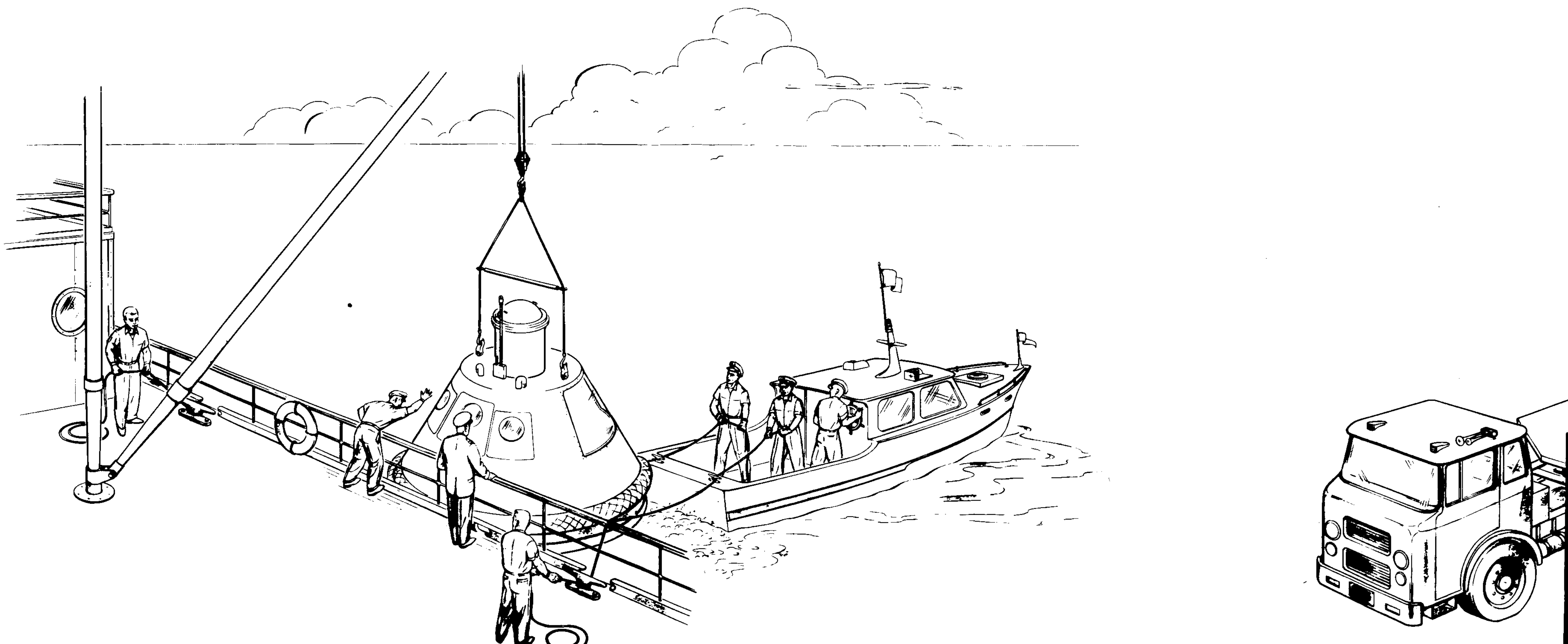


COLD WEATHER RECOVERY / SURVIVAL TRAINING

DESERT RECOVERY/ SURVIVAL TRAINING



SEA RECOVERY/ SURVIVAL TRAINING



EGRESS TRAINER HANDLING ACTIVITIES

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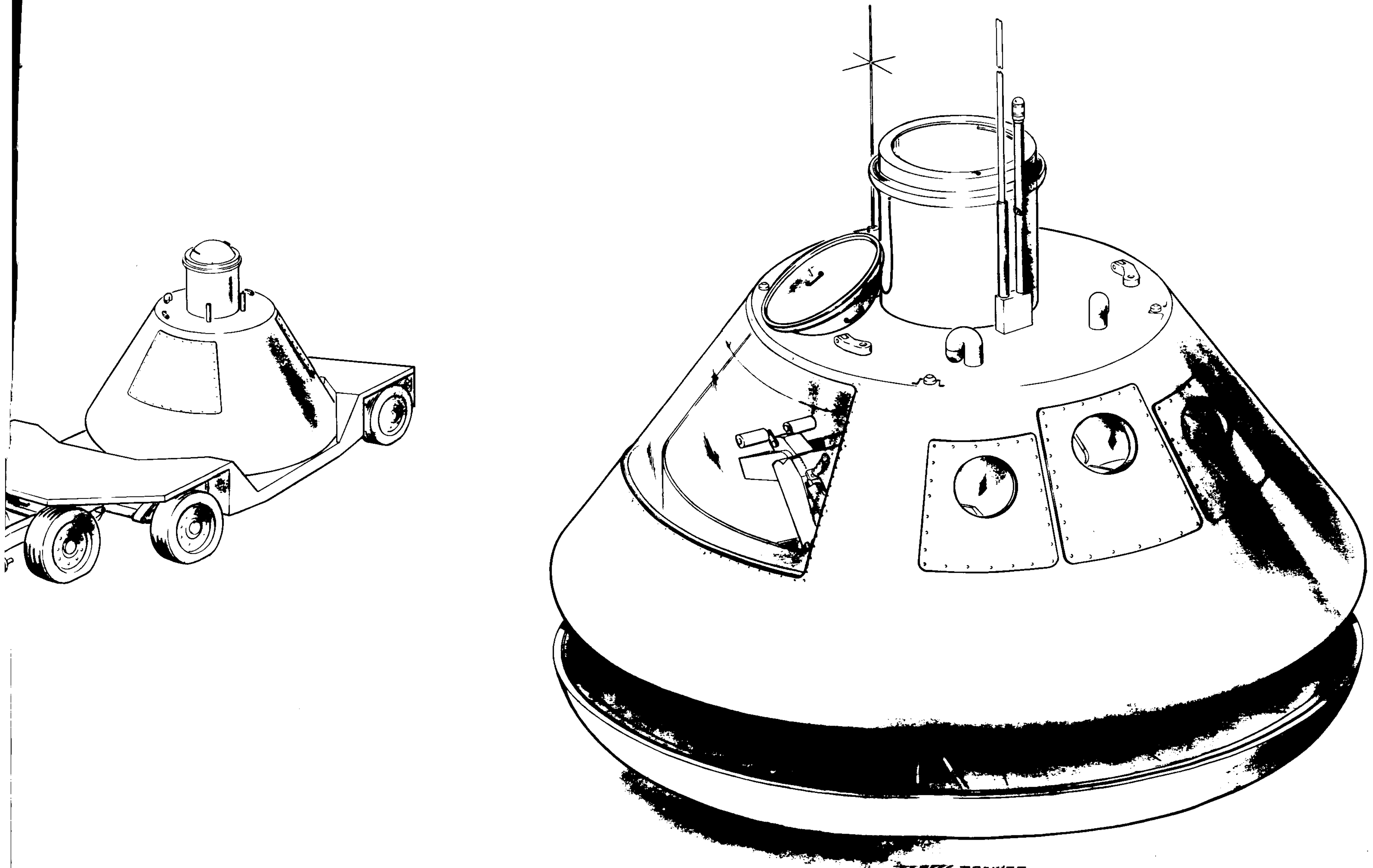

EGRESS TRAINER

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LIST OF MATERIAL OR PARTS LIST

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APPLICATION (USAGE) DATA

HEAT TREAT

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DECIMALS ANGLES
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.XXX = ± .010 ± 30'
HOLES NOTED "DRILL"
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.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
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SPACE and INFORMATION SYSTEMS DIVISION
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TRAINER-EGRESS, PART TASK

CODE IDENT NO.	SIZE	
03953	J	T14-860007
SCALE		SHEET

3.3.2 Moon Base Operation Trainer (T14-860008)

3.3.2.1 Description

The Moon Base Operation Trainer will provide integrated crew training in post lunar landing activities as related to lunar surface entry, surveillance, scientific exploration and return to spacecraft. The trainer will be mounted upon a limited model of the lunar surface representative of the projected lunar landing and surveillance area.

3.3.2.2 Performance Capabilities

The trainer will be capable of simulating the performance characteristics of spacecraft systems required for post lunar landing activities and will provide facilities for lunar surface activities extraneous to the spacecraft. Normal and alternate lunar egress procedures will be exercised. The trainer will provide the following moon base operational parameters:

Simulated Spacecraft Operation Duty Cycles

Spacecraft Egress-Ingress Procedures Including Airlock Operation

Spacecraft Off-Loading, On-Loading Tasks

Inspection of Spacecraft for Structural Damage (meteroid collision, landing impact, etc.)

Lunar Surveillance and Scientific Exploration

Life Support and Survival Equipment Operation

Crew Member Intercommunication

[redacted]

DSIF Communication

Lunar Pre-Launch Activities

3.3.2.3 General Equipment Requirements

The following minimum major equipments will be required to provide complete and effective crew member training in post lunar landing operations.

3.3.2.3.1 Simulated Spacecraft

The simulated spacecraft will consist of a combined command module, service module and lunar landing module mockup, structurally and physically representative of the external structure of the actual spacecraft in the post lunar landing configuration. Internal arrangement of the command module mockup will represent the actual command module with respect to size, shape, and equipment location. Controls and displays which are functionally operable during the specified phase will be physically and operationally representative of the controls and displays in the actual module. Consideration will be given to simulating typical spacecraft structural damages to provide crew member motivation for post lunar landing structure inspection and potential repair.

3.3.2.3.2 Operator Station

The operator's station will provide the proper inputs to the simulated spacecraft for initiating crew member activities related to spacecraft egress. The station will consist of controls and displays for providing the following functions:

~~CONFIDENTIAL~~

Representative spacecraft operational system readouts and controls

Selection of normal or alternate crew egress

Intercommunication with crew members

Reception of data transmitted by crew members from lunar surface model

3.3.2.3.3 Lunar Surface Model

The model of the lunar surface will duplicate the anticipated terrain and celestial features and immediate environs of the lunar landing area. The model will be limited in size and accurately scaled to provide realism in the lunar environment for crew member observation, surveillance, scientific exploration and equipment utilization during post lunar landing operations external to the spacecraft. Provisions for sound damping will be included.

3.3.2.3.4 Air Conditioning Equipment

Air conditioning equipment will be provided for internal ventilation and ambient temperature control of the simulated spacecraft. Where ambient temperature control is required external to the simulated spacecraft, air conditioning will be provided. Ambient lunar light conditions will be simulated.

3.3.2.3.5 Power Equipment

Power generation, distribution and control equipment will be provided as required.

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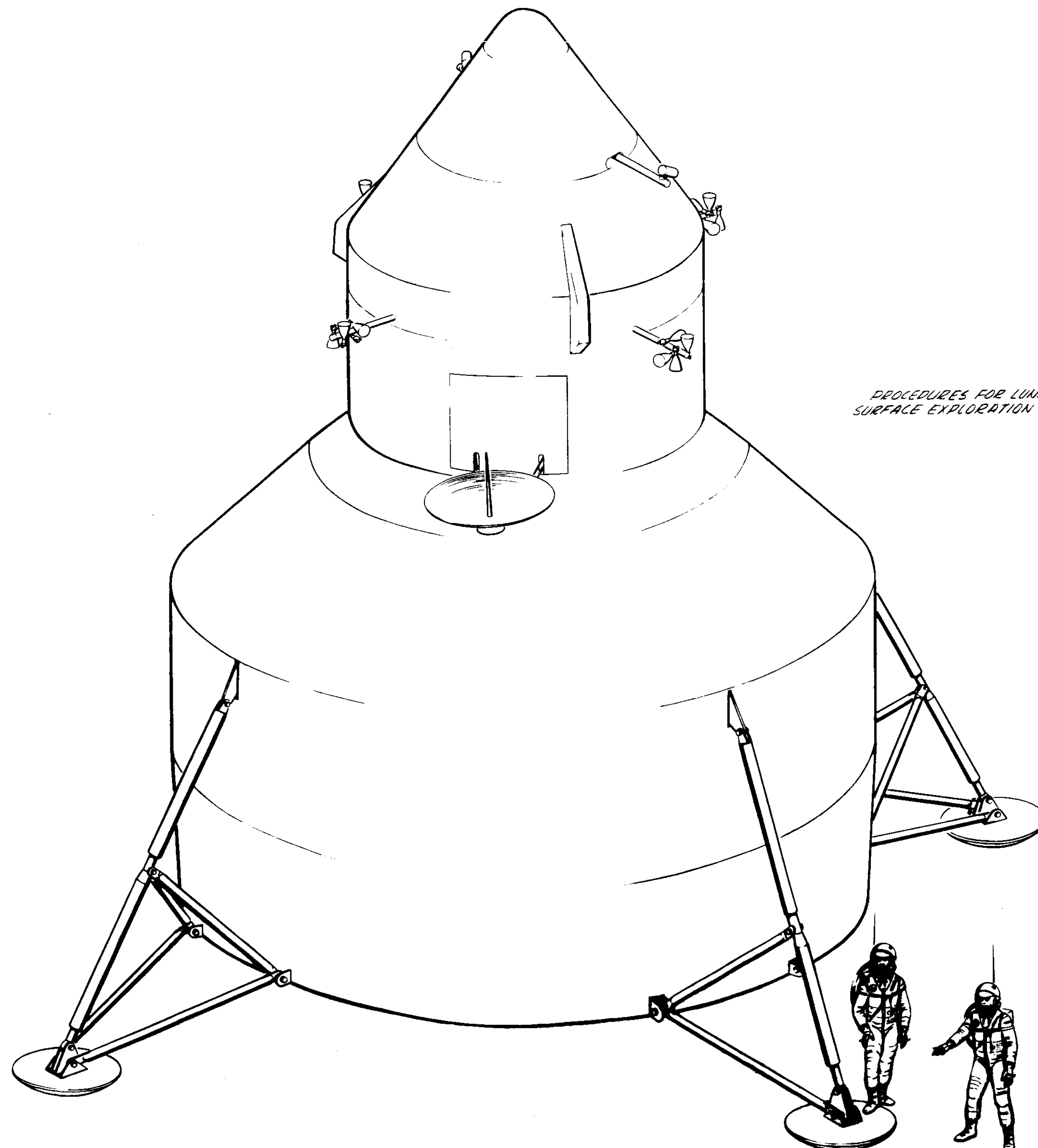
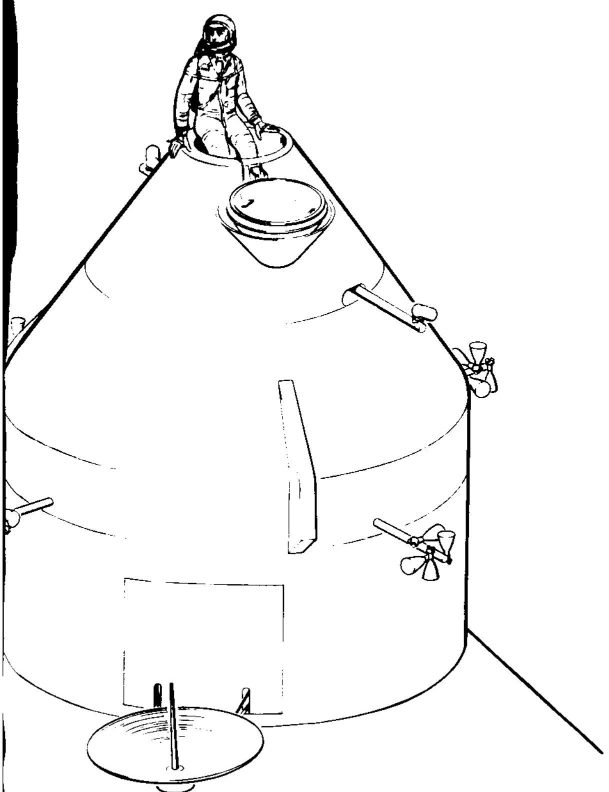
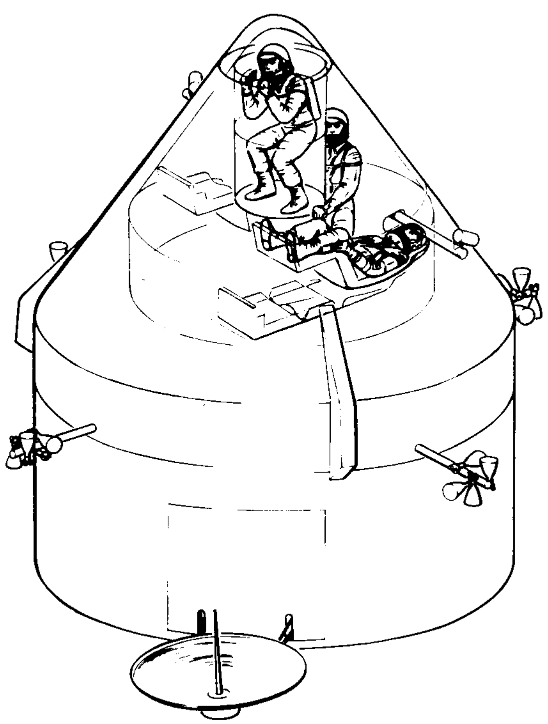
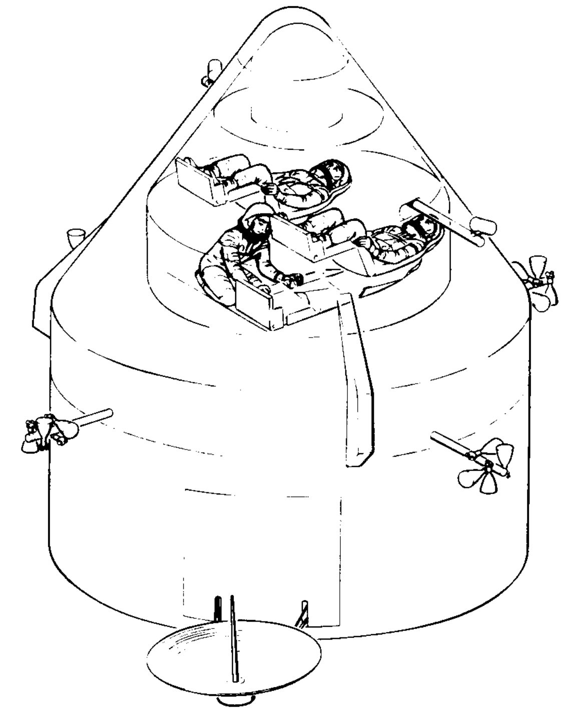




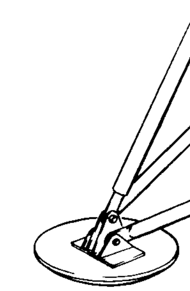
PROCEDURES FOR S/C
EXTERIOR DAMAGE EVALUATION

LUNAR SURFACE EGRESS PROCEDURES





PROCEDURES PREPARATORY
TO EGRESS ON LUNAR SURFACE



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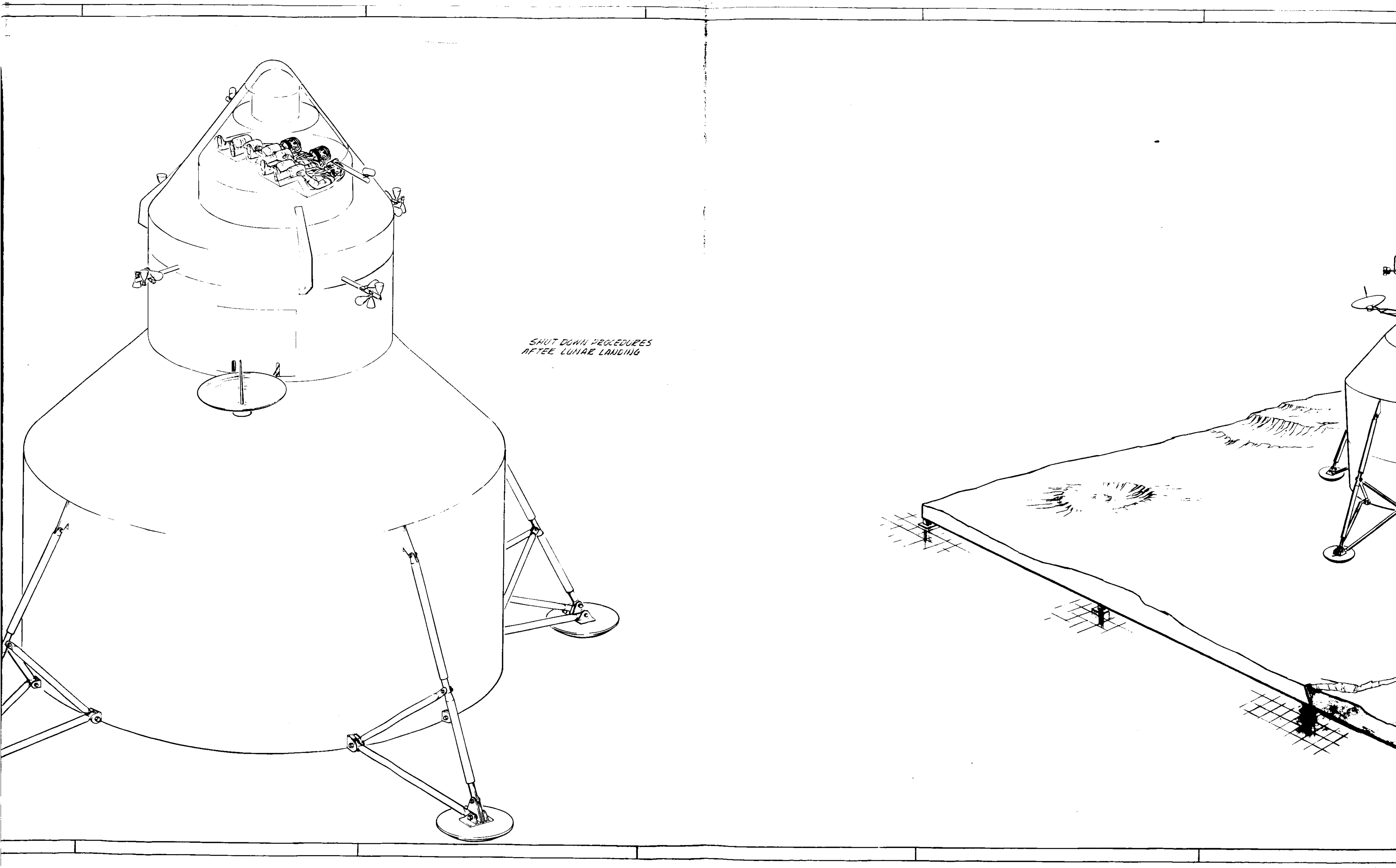

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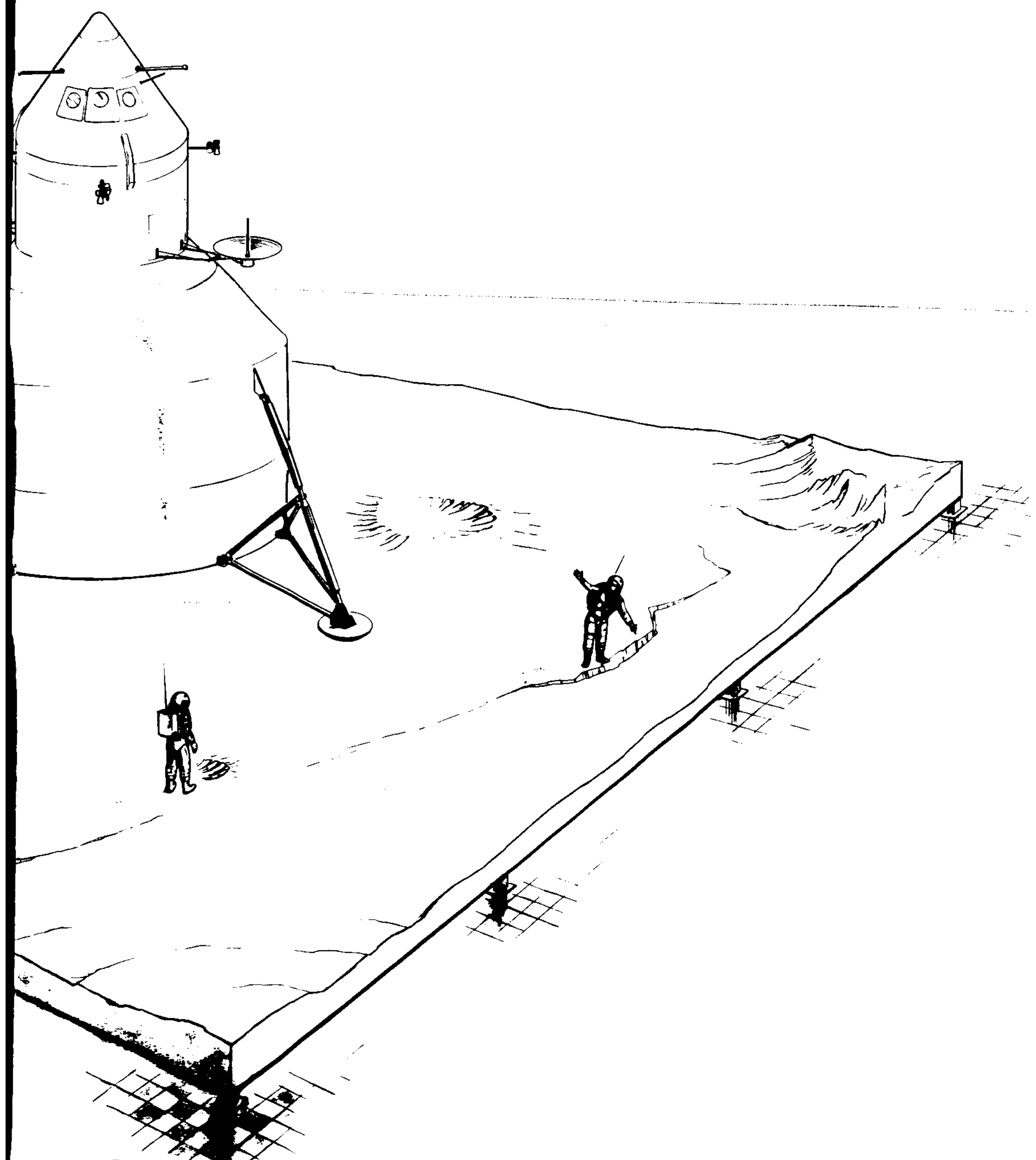

PURPOSE

1. TO ANALYZE AND EVALUATE ALL PROBLEMS ASSOCIATED WITH ENTRY FROM THE SPACECRAFT ONTO THE LUNAR SURFACE AND REENTRY INTO THE SPACECRAFT.
2. TO CONDUCT TIME/MOTION STUDIES.
3. TO ACHIEVE A HIGH PROFICIENCY IN THE PROPER EGRESS AND INGRESS PROCEDURE BY EXTENSIVE TRAINING IN THE SIMULATOR.
4. TO UPDATE THE LUNAR SURFACE MOCKUP AND EGRESS/INGRESS PROCEDURES AS LATER DATA IS RECEIVED.

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TRAINER -
MOON BASE OPERATION,
PART TASK

CODE IDENT NO. 03953 SIZE J T-14-860008

SCALE SHEET

3.3.3 Weightless Procedures Trainer (T14-860009)

3.3.3.1 Description

The Weightless Procedures Trainer is a device that will simulate free-floating conditions and will provide for the safe training of a three man space crew in developing skills realtive to the activities, within and external to, the command module under free-floating conditions. The module is completely filled with and submerged in water. The Weightless Procedures Trainer will also provide training for crew members in the expedient emergency egress from a submerged vehicle.

3.3.3.2 Performance Characteristics

The trainer will be designed to provide crew performance training in underwater stress environment. The primary functions of this device are to:

a. Analyze and evaluate the problems of crew motility under simulated free-floating conditions.

b. Train crew members in the location and operation of various equipments and controls under conditions of unusual body attitudes and command module reference.

c. Provide crew training in expedient egress from a submerged capsule.

d. Conduct time/motion studies as related to crew activities within and external to, the submerged simulated command module.

e. Permit observation and recording of various problems associated with crew orientation under simulated conditions for future space crew indoctrination.

The simulated command module will be gimballed through a supporting structure to allow rotation in a single degree of freedom through 360° in the pitch axis. This freedom of rotation will allow either random lock-in positioning at any point to simulate momentary or lengthy capsule attitudes, or continuous rotation of the command module to simulate tumbling effects. The control of the gimballed axis rotation will originate from the remote instructor operator station(s). This rotational action will provide additional crew training relative to the orientation and utilization of capsule control equipment during various pitch attitudes. Mechanical controls will be available within the simulated command module pertinent to hatch removal and airlock operation.

3.3.3.3 General Equipment Requirements

To provide for the complete and effective crew training, and to perform the analytical studies of crew motility problems under free-floating conditions, the following major assemblies are required.

3.3.3.3.1 Simulated Command Module

The simulated command module will be an authentic replica of the actual module with regard to interior and exterior shape and size. The interior configuration will include complete synthetic mockups of controls, displays, equipment, couches, etc. All mocked up equipments will be representative of the actual size, shape, and location as found in the actual command module. Windows, hatches, air lock and such operable mechanical controls and structure necessary for complete simulation will be duplicated and operational.

An illumination system together with a closed circuit television system will be provided and installed within the simulated command module. The TV cameras will record and display through remote monitors the action of crew performances within the capsule during various module attitudes and training phases. Personal propulsion devices, as part of the space suit assembly, will be provided to enable crew members to transport themselves within and out of the module as simulation of space weightlessness. Removable command module instrument and control panels for assigned repair and maintenance tasks will be provided. To enable rapid emergency exit from the simulated command module, break away panels and other structure sections will be incorporated.

The simulated command module will be supported by a frame structure such that a rotational movement about the pitch axis of 360° will be accomplished. This rotation will be capable of forward and reverse directions and be either intermittent or constant to simulate various pitch attitudes during actual flight conditions. The full control of pitch axis rotation relative to direction, speed, duration and holding will be from the remote instructor-operator station console.

The materials used in fabricating the module will be unaffected by extended underwater usage. The external shell structure will be fabricated of transparent material to allow observers to monitor crew member activities within and exterior to the simulated command module. The shell structure will be such that provisions for immediate egress through a monitoring and observation cutout in the command module wall will be available in the event of an emergency.

3.3.3.3.2 Water Tank

The water tank to enclose the simulated command module will consist of a cylindrical vessel and will be of adequate size and capacity to completely submerge the module through a 360° rotation, regardless of trainer attitude. The single axis rotational support structure (for mounting the module) will be attached to the base of the tank interior. Observation platforms and viewing ports will encircle the tank exterior for complete unobstructed surveillance and recording of capsule events and crew activity. Illumination ports and flood lights will be mounted on the exterior structure of the tank to provide underwater illumination for improved visibility.

3.3.3.3.3 Water Control Equipment

The equipment required for the filling, draining, and maintenance of the water tank will consist primarily of a recirculating water supply including water pumps, filters, heaters, control valves and plumbing as required for the interconnections between the tank and water supply.

3.3.3.3.4 Recording and Monitoring Equipment

A closed circuit television system will be installed to provide supplemental data for remote classroom instruction and observation of the actual training activities. Motion picture cameras will provide permanent recordings to aid time and motion studies for future space crew indoctrination.

3.3.3.3.5 Operator Station

The operator's station will consist of a simplified console containing all controls required for managing:

Pitch attitudes of the simulated command module

Intercommunication between operator and all observers

Underwater tank illumination

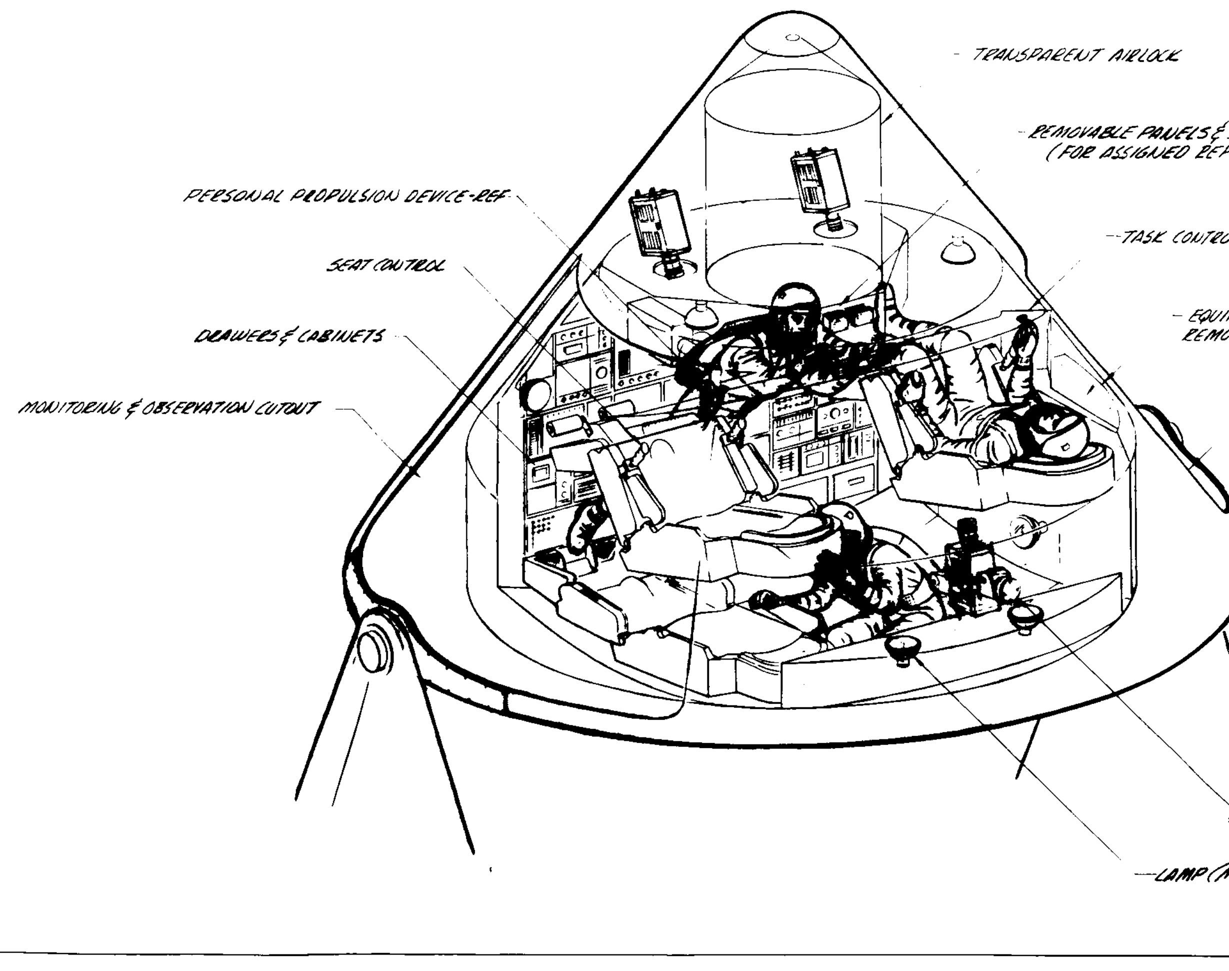
Command module interior illumination

Command module interior television cameras

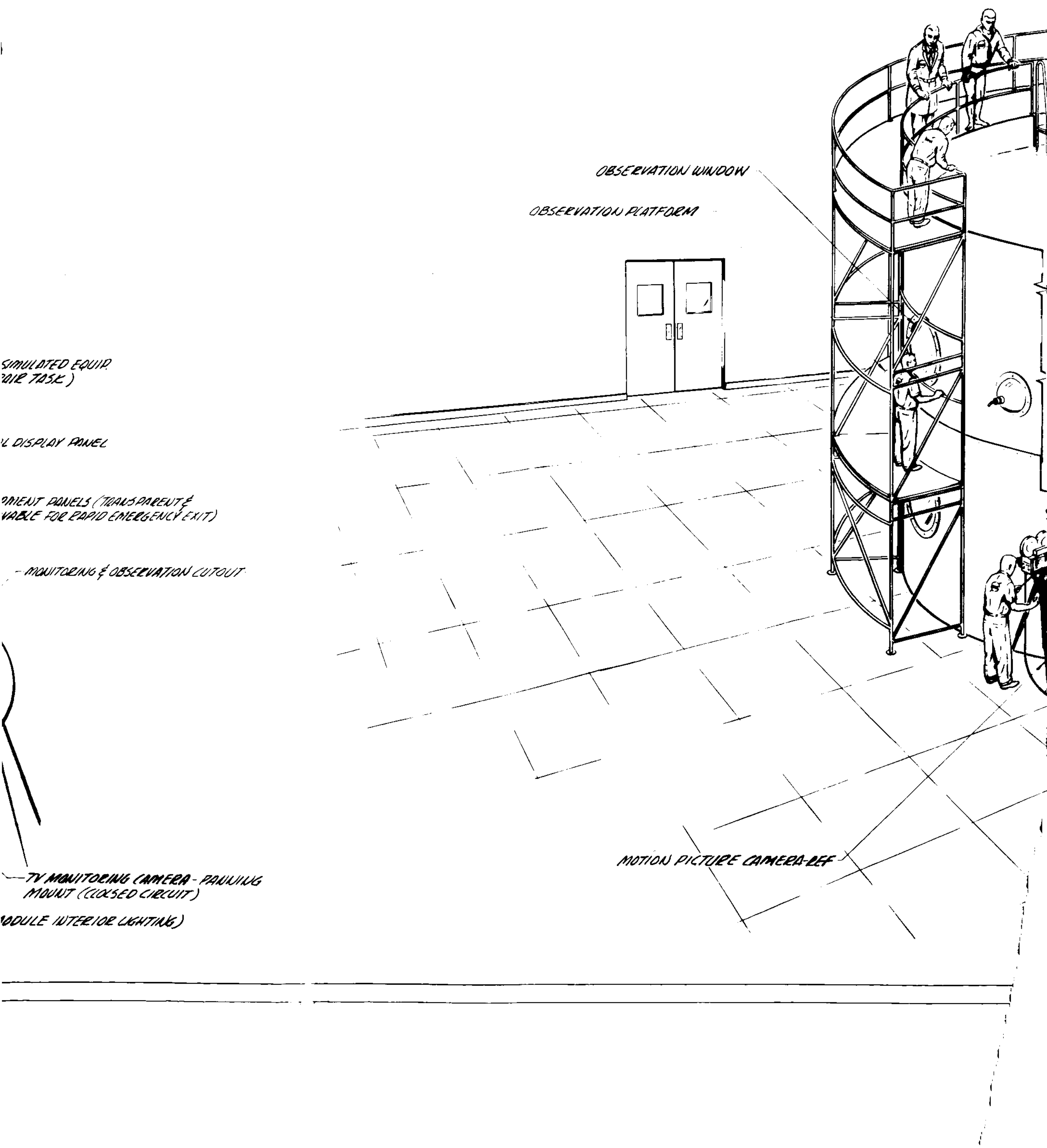
3.3.3.3.6 Power Equipment

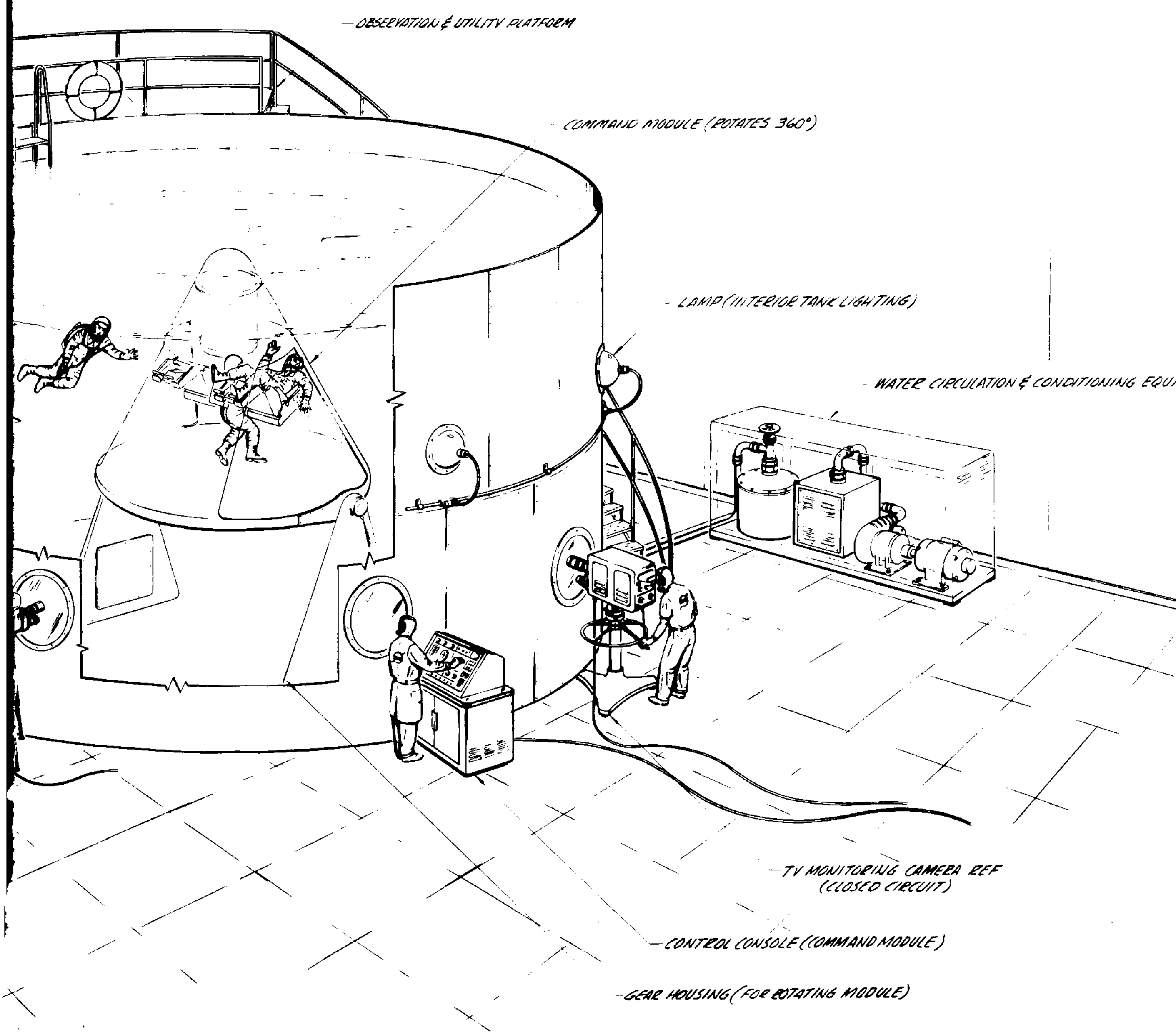
Power generation, distribution and control equipment will be provided as required.

1 OF 4


TRANSPARENT AIRLOCK
PERSONAL PROPULSION DEVICE-REF
SEAT CONTROL
DRAWERS & CABINETS
MONITORING & OBSERVATION CUTOUT

#2 OF 4


OBSERVATION WINDOW
OBSERVATION PLATFORM
SIMULATED EQUIP.
PAIR TASK)
L DISPLAY PANEL
PMENT PANELS (TRANSPARENT &
VABLE FOR RAPID EMERGENCY EXIT)
MONITORING & OBSERVATION CUTOUT
TV MONITORING CAMERA - PANNING
MOUNT (CLOSED CIRCUIT)
ODULE INTERIOR LIGHTING)
MOTION PICTURE CAMERA-REF



OBSERVATION & UTILITY PLATFORM
COMMAND MODULE (ROTATES 360°)
LAMP (INTERIOR TANK LIGHTING)
WATER CIRCULATION & CONDITIONING EQUI
TV MONITORING CAMERA REF (CLOSED CIRCUIT)
CONTROL CONSOLE (COMMAND MODULE)
GEAR HOUSING (FOR ROTATING MODULE)

#4 OF 4

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK		

PURPOSE

1 TO ANALYZE & EVALUATE THE PROBLEMS OF CREW MOTILITY UNDER SIMULATED FREE FLOATING CONDITIONS
2 TO TRAIN ASTRONAUT CREWS IN THE LOCATION & OPERATION OF VARIOUS EQUIPMENT & CONTROLS UNDER CONDITIONS OF UNUSUAL BODY ATTITUDES & SPACE CRAFT REFERENCE
3 TO CONDUCT TIME/MOTION STUDIES
4 TO PERMIT OBSERVATION & RECORDING OF VARIOUS PROBLEMS ASSOCIATED WITH CREW ORIENTATION UNDER SIMULATED CONDITIONS FOR FUTURE SPACE CREW INDOCTRINATION

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							T14-860009	TRAINER				001
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LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
	PER END ITEM			EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:

DECIMALS	ANGLES
.XX= ± .03	
.XXX= ± .010	± 30'

HOLES NOTED "DRILL"

.013	THRU	.040	+ .001 - .001
.041	THRU	.130	+ .002 - .001
.131	THRU	.229	+ .003 - .001
.230	THRU	.500	+ .004 - .001
.501	THRU	.750	+ .005 - .001
.751	THRU	1.000	+ .007 - .001
1.001	THRU	2.000	+ .010 - .001

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TRAINER - WEIGHTLESS PROCEDURES, PART TASK

CODE IDENT NO. 03953 | SIZE J | T-14-860009

SCALE NONE | SHEET

3.4 <u>Module System Trainers (Maintenance Trainers)</u>

The Module System Trainers will be designed to facilitate the transfer of knowledge and attainment of proficiency required for understanding of the major systems, and for the performance of tasks and procedures relative to maintenance and checkout of the Apollo systems. These tasks and procedures include removal and replacement of components, malfunction isolation and correction, use of GSE, and system alignment, adjustment, calibration, etc., as required by system design. Each trainer will be provided with an instructor's station which will include controls and displays required for effective system demonstration. Each trainer will be supplied with appropriate power equipment required for system activation. Individual trainer configuration is dependent upon the system characteristics and will be as described in the following paragraphs.

[redacted]

3.4.1 **Service Module Propulsion System Trainer (T14-860015)**

The Service Module Propulsion System Trainer will provide training through demonstration and practice, in system flow, checkout, adjustment, removal, replacement and repair of components, and system servicing. The trainer will consist of the following major sections:

a. A layout of the system, including components and/or facsimiles of components, lines and wiring mounted in their proper relation on a vertical display panel. Where feasible, components will be sectionalized to demonstrate internal operation. The sectionalized components will be mounted so that they may be removed for individual demonstration of part replacement and servicing. Components will be operable where operation is advantageous to training. Redundant portions of the system will not be included. Crew controls and displays and instructor controls, to insert malfunctions and signals from related systems, will be incorporated in a trainer op[illegible] console.

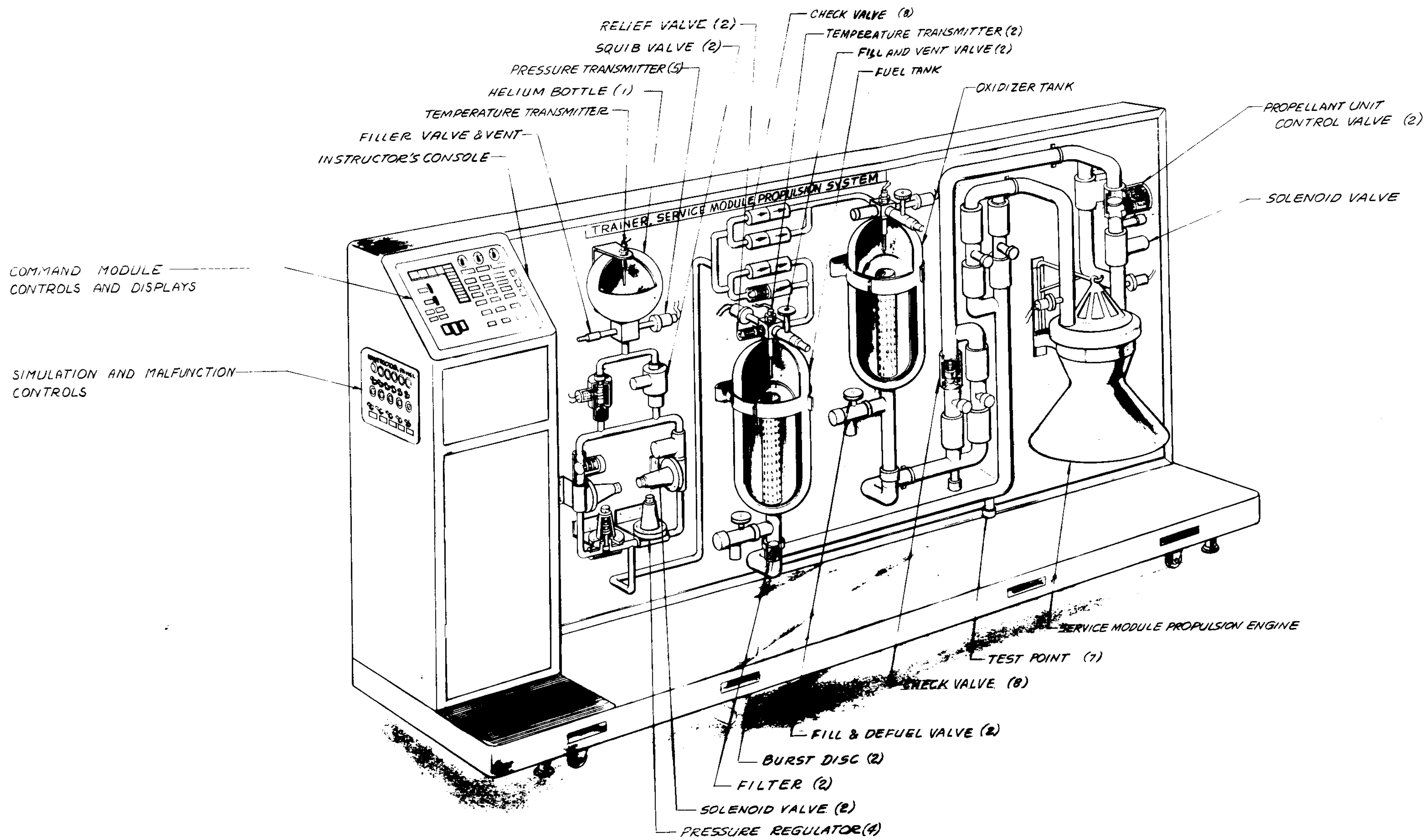
b. Audio-visual section to present system flow, component location, checkout points, etc. This trainer will back project translucent training material, such as schematics, flow diagrams, component details, etc., on a screen. Motion, where required, will be simulated by polarization methods. The audio section will be synchronized with the individual visual presentations to give descriptive information.

~~CONFIDENTIAL~~

c. Liquid and gas tanks, together with necessary plumbing; and the engine gimbal mount and actuators, mounted on a frame structure. This section of the trainer will be designed to operate with fuel, oxidizer, and He GSE transfer units. To afford practice in handling procedures, the tanks may be filled and drained as in the spacecraft, but non-hazardous liquids may be used. The engine mount section may be separated from the tank section for instruction on the operation and adjustment of the actuators, which will be operable.

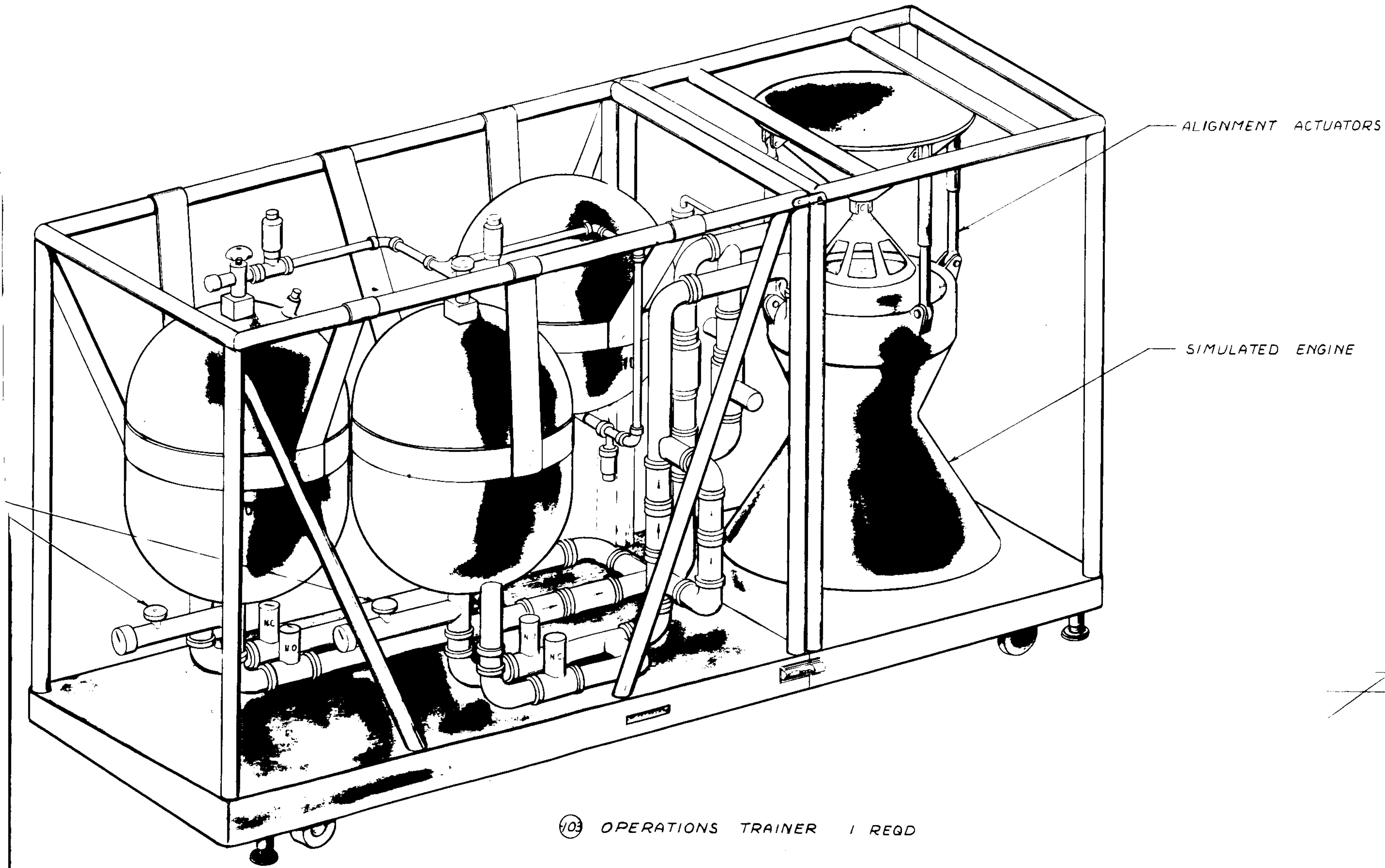
d. GSE transfer units.

e. Power supply equipment.

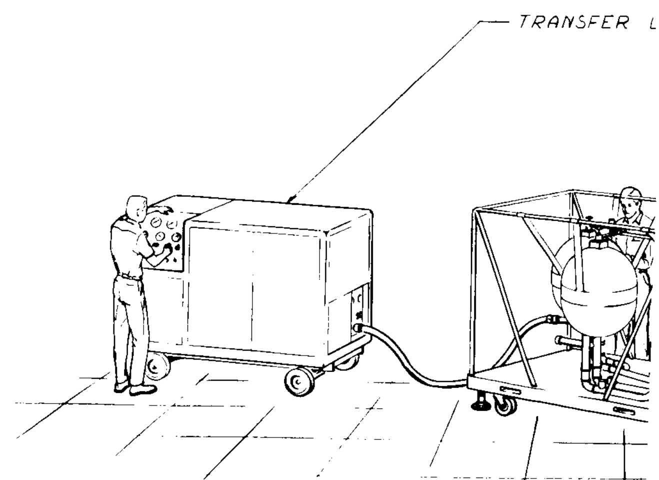


FILL AND DEFUEL VALVES

-101 SYSTEM TRAINER 1 REQD



(103) OPERATIONS TRAINER 1 REQD



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REVISIONS

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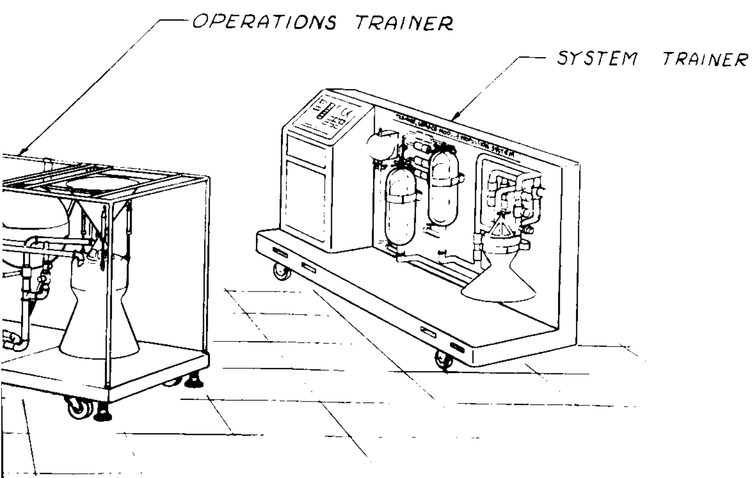

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						T14-860015	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

REQD QTY	QTY REQD PER END ITEM	NEXT USING DRAWING	END ITEM NO.	THRU
				EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS ANGLES
.XX= ± .03
.XXX= ± .010 ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001

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TRAINER, SERVICE MODULE PROPULSION SYSTEM, (MAINTENANCE)

CODE IDENT NO. 03953 | SIZE J | T14-860015

SCALE NONE | SHEET 1 OF 1

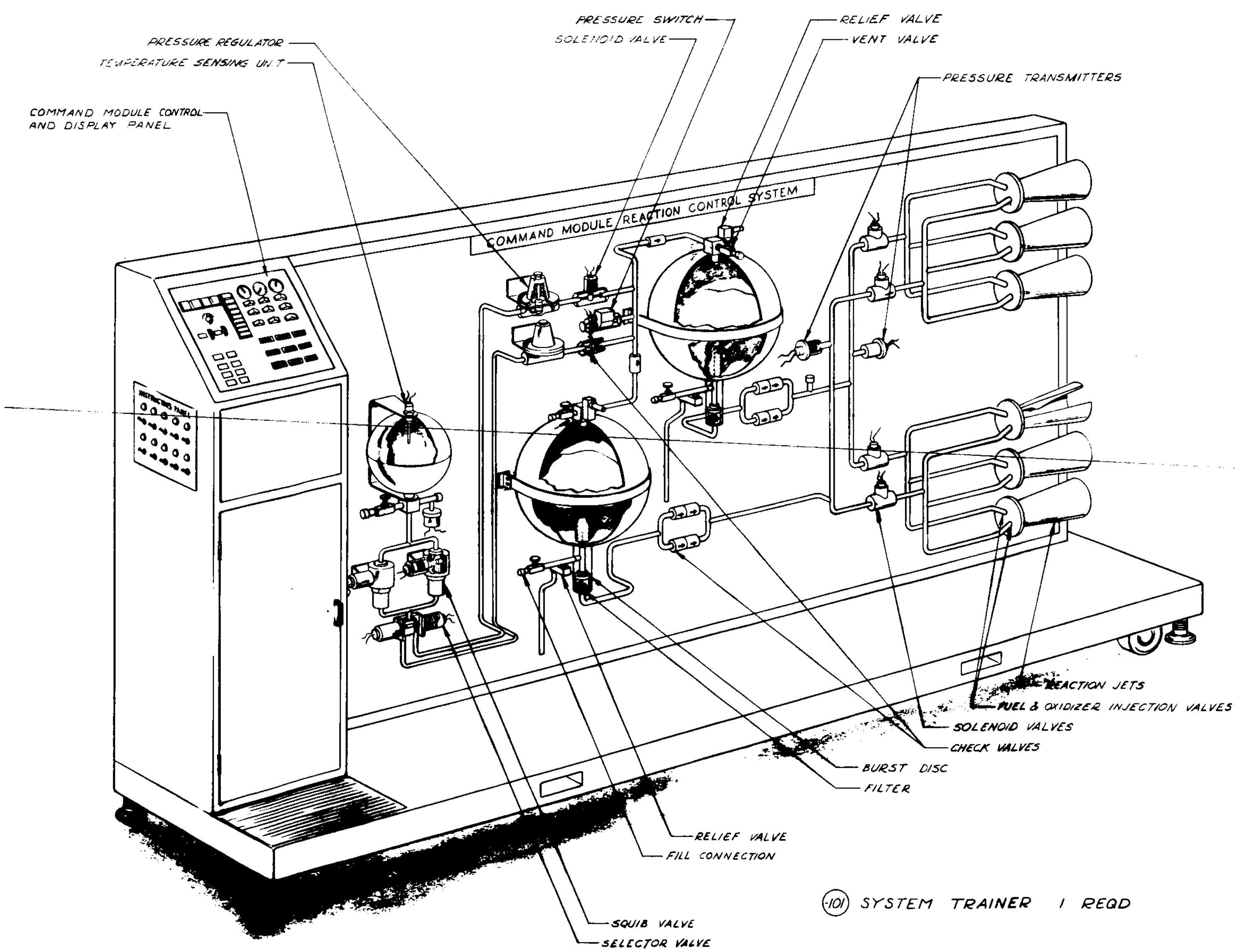
3.4.2 Command Module Reaction Control System Trainer (T14-860016)

The Command Module Reaction Control System Trainer will provide training, through demonstration and practice, in system flow, checkout, and removal, replacement and repair of components. The trainer will consist of the following major sections:

a. A layout of the system, including components and/or facsimiles of components, lines and wiring, mounted in their proper relation on a vertical display panel. Where feasible, components will be sectionalized to demonstrate internal operation. The sectionalized components will be mounted so that they may be removed for individual demonstration of parts replacement and servicing. Components will be operable where operation is advantageous to training. Redundant portions of the system will not be shown. Crew controls and displays and instructor controls to insert signals from other systems and malfunction indications will be incorporated in the trainer operation console.

b. Audio-visual section to present component location, system flow, checkout points, etc. This section will back project translucent training material, such as schematics, flow diagrams, component details, etc., on a screen. Motion, where required, will be simulated by polarization methods. The audio section will be synchronized with the individual visual presentations to give descriptive information.

c. Power supply equipment.



(101) SYSTEM TRAINER 1 REQD

#2 of 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
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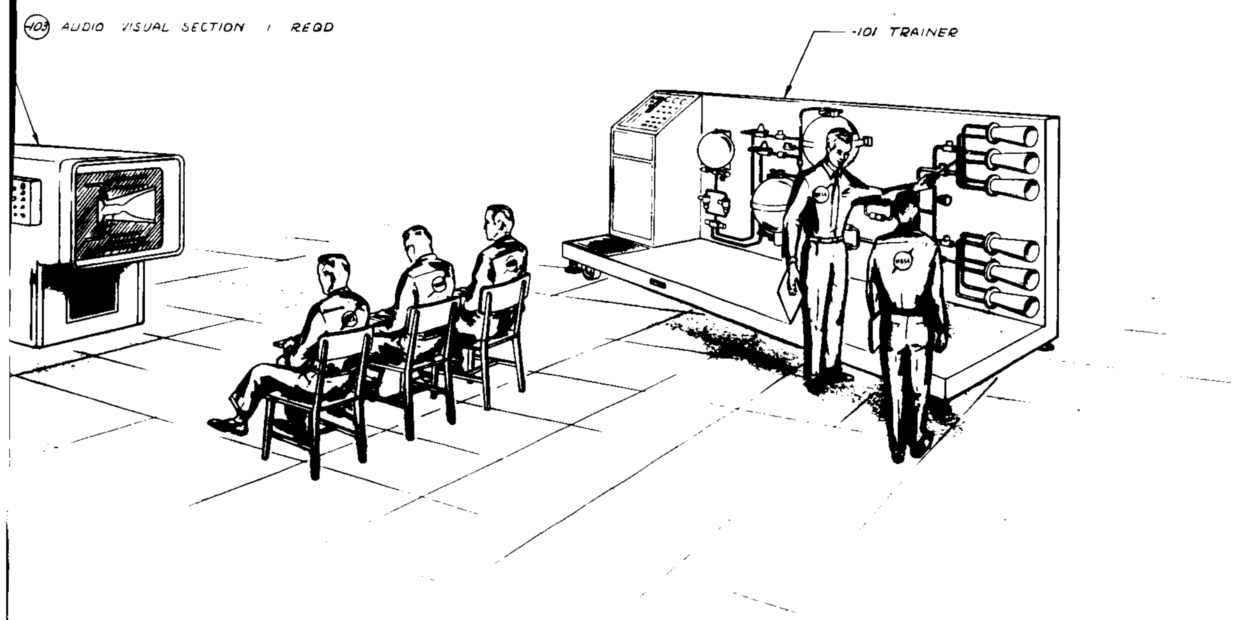

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						T14-860016	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM	Q/TY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS ANGLES
.XX = ± .03
.XXX = ± .010 ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
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TRAINER — COMMAND MODULE REACTION CONTROL SYSTEM, MAINTENANCE

CODE IDENT NO.	SIZE	
03953	J	T14-860016
SCALE NONE		SHEET

3.4.3 <u>Service Module Reaction Control System Trainer (T14-860017)</u>

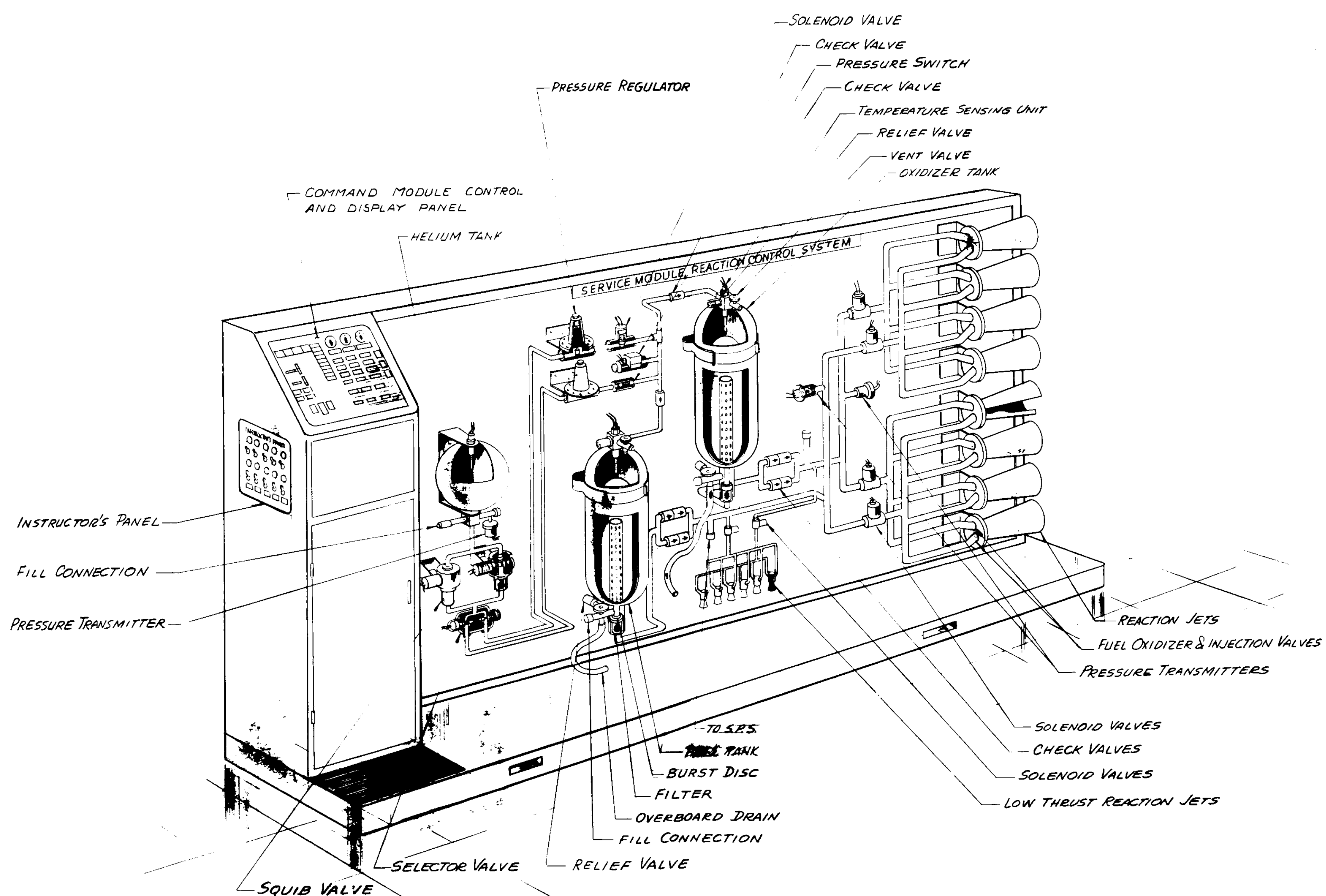
The Service Module Reaction Control System Trainer will provide training, through demonstration and practice, in system flow, checkout, and removal, replacement, and repair of components. The trainer will consist of the following major sections:

a. A layout of the system, including components and/or facsimiles of components, lines, and wiring, mounted in their proper relation on a vertical display panel. Where feasible, components will be sectionalized to demonstrate internal operation. The sectionalized components will be mounted so that they may be removed for individual demonstration of part replacement and servicing. Components will be operable where operation is advantageous to training. Redundant portions of the system will not be displayed. Crew controls and displays and instructor controls to insert signals from related systems and malfunction indications will be incorporated in a trainer operation console.

b. Audio-visual section to present component location, checkout points, system flow, etc. This section will back project translucent training material, such as schematics, flow diagrams, component details, etc., on a screen. Motion, where required, will be simulated by polarization methods. The audio portion will be synchronized with the individual visual presentations and will give descriptive information.

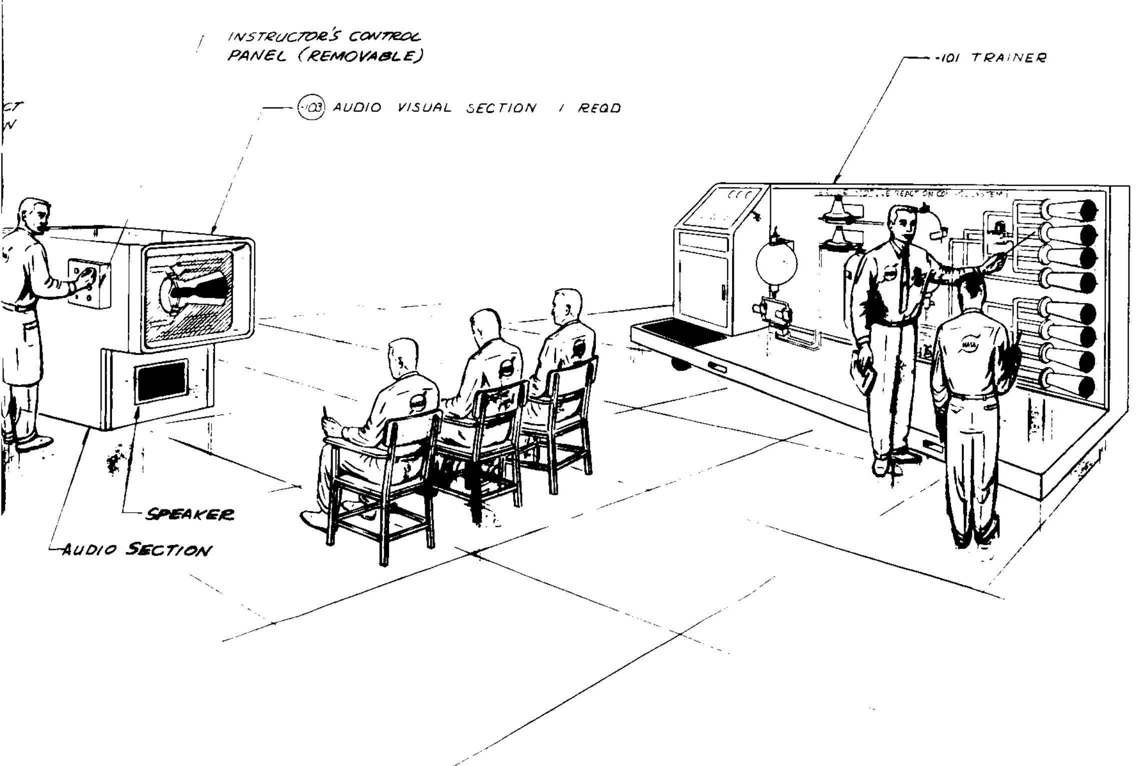
c. Power supply equipment.

#1 02



(101) SYSTEM TRAINER 1 REQD

REVISIONS					
SYM	ZONE	DESCRIPTION	DISPOS	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE ON			



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						T14-860017	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM REQD	QTY PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU / EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS ANGLES
.XX= ± .03
.XXX= ± .010 ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
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TRAINER-SERVICE MODULE REACTION CONTROL SYSTEM

CODE IDENT NO. 03953 | SIZE J | T-14-860017

SCALE | SHEET 1 OF 1

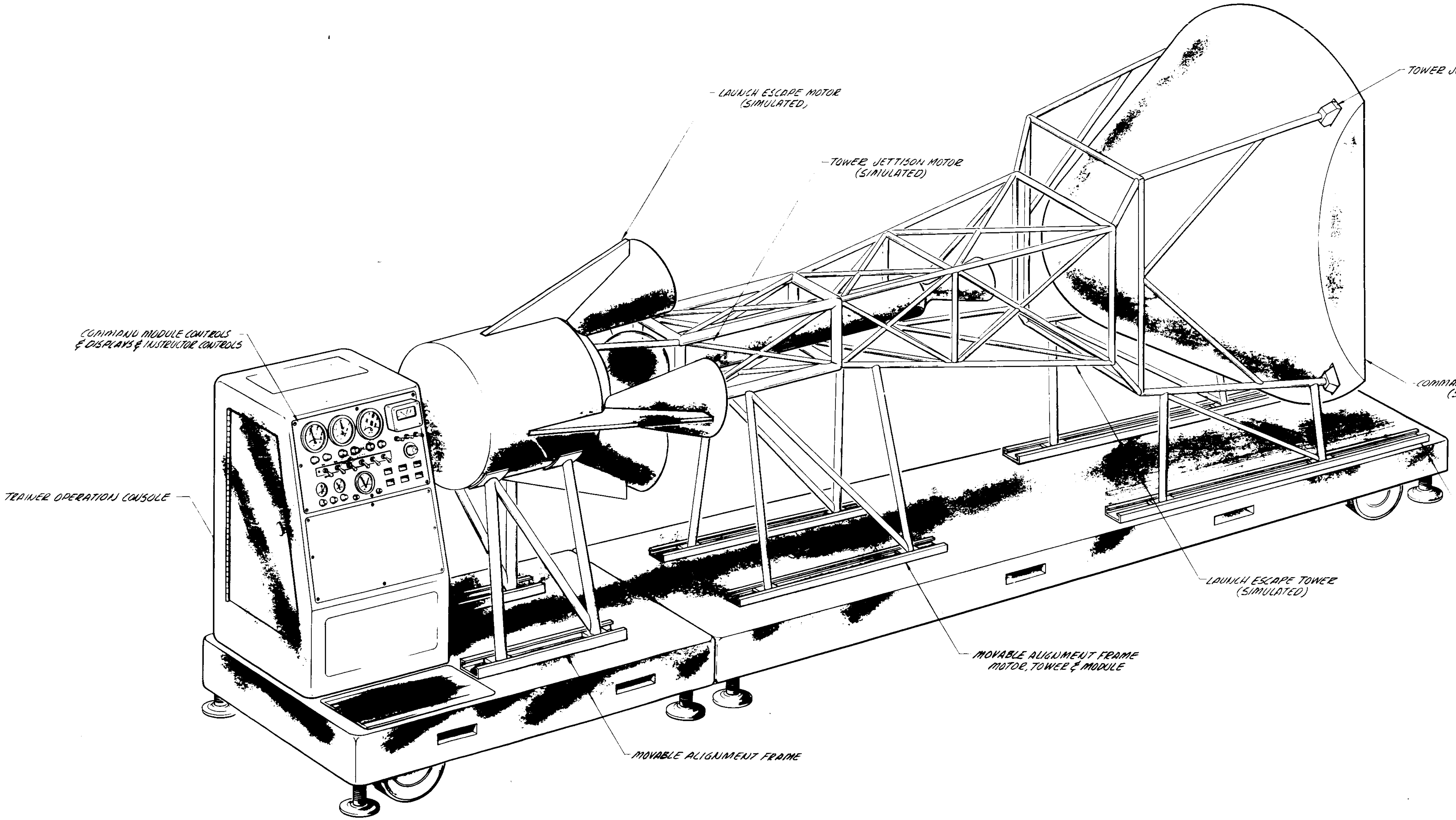
[redacted]

3.4.4 Launch Escape System Trainer (T14-860018)

The Launch Escape System Trainer will provide training, through demonstration and practice, in system operation, checkout, installation and adjustment including the tower jettison system.. The trainer will consist of the following:

a. A frame structure supporting a simulated lower tower section with actual disconnect mounts (disarmed); a simulated upper tower section mounting simulated launch escape motor and tower jettison motor with actual adjustable mounts; and a trainer operation console. The console will incorporate the command module controls and displays, and instructor controls which will provide simulated signals to initiate launch escape or jettison sequences and selected malfunction indications. System electrical circuits will be duplicated.

b. Power supply equipment.


LAUNCH ESCAPE MOTOR (SIMULATED)
TOWER JETTISON MOTOR (SIMULATED)
TOWER JET
COMMAND MODULE CONTROLS & DISPLAYS & INSTRUCTOR CONTROLS
TRAINER OPERATION CONSOLE
COMMAND (SI
LAUNCH ESCAPE TOWER (SIMULATED)
MOVABLE ALIGNMENT FRAME MOTOR, TOWER & MODULE
MOVABLE ALIGNMENT FRAME

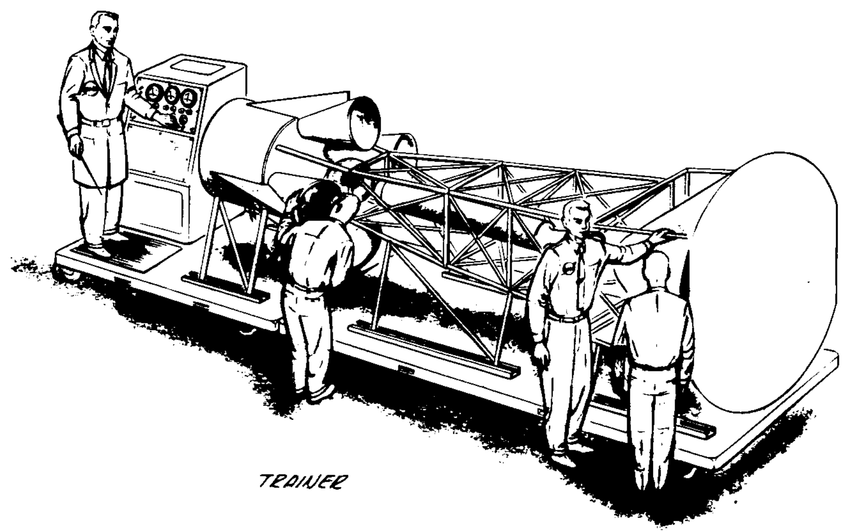
2 of 2

REVISIONS					
SYM	ZONE	DESCRIPTION	DISPOS	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK			

...TISON ATTACHMENT

...MODULE NOSE
...IULATED)

MOVABLE ALIGNMENT FRAME



TRAINER

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						T14-860018	TRAINER					

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
				EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS ANGLES
.XX = ± .03
.XXX = ± .010 ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .220 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
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CHK BY
APPROVED BY [signature]

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12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER -
LAUNCH ESCAPE SYSTEM,
MAINTENANCE

CODE IDENT NO. 03953 | SIZE J | T-14-860018

SCALE | SHEET

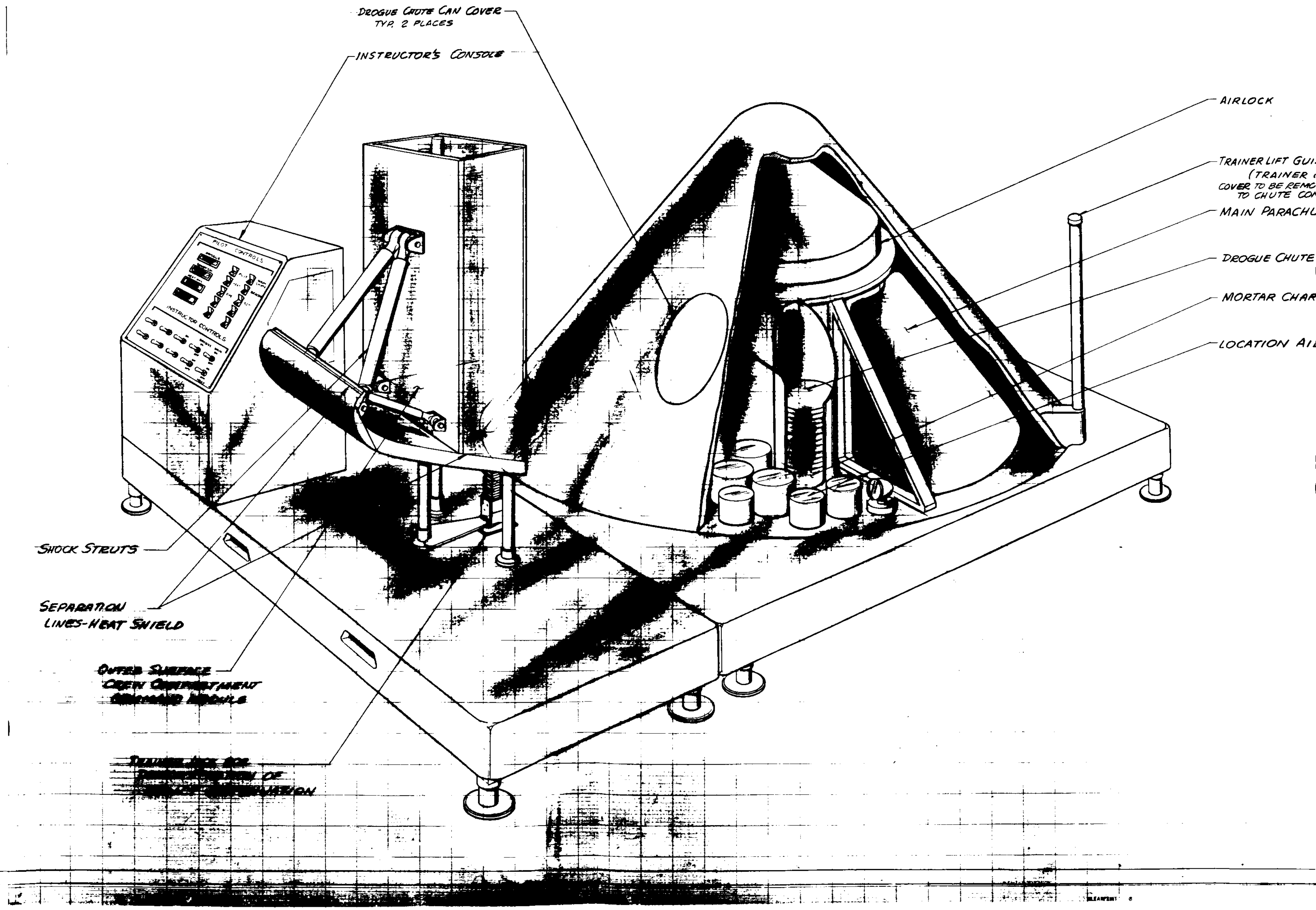
3.4.5 Earth Landing System (Parachute) Trainer (T14-860019)

The Earth Landing System Trainer will provide training, through demonstration and practice, in sequential system operation, checkout, and installation. The trainer will consist of the following major sections:

a. A suitable structure supporting a simulated parachute compartment, a simulated section of the lower heat shield, and a trainer operation console. The simulated parachute compartment will incorporate a removable cover, actual parachute attachment devices, facsimile main and drogue parachutes, expulsion and jettison devices (disarmed) and facsimile location aids. The simulated heat shield section will include one set of impact attenuation struts and will be so designed that extension, retraction, adjustment, and servicing of the impact attenuation system may be demonstrated and practiced. The trainer operation console will include command module controls and displays; instructor controls to initiate sequencing and to introduce malfunction indications; simulation equipment to provide sequencing signals; and system circuitry to provide for use of GSE checkout equipment.

b. GSE checkout console

c. Power Supply equipment.

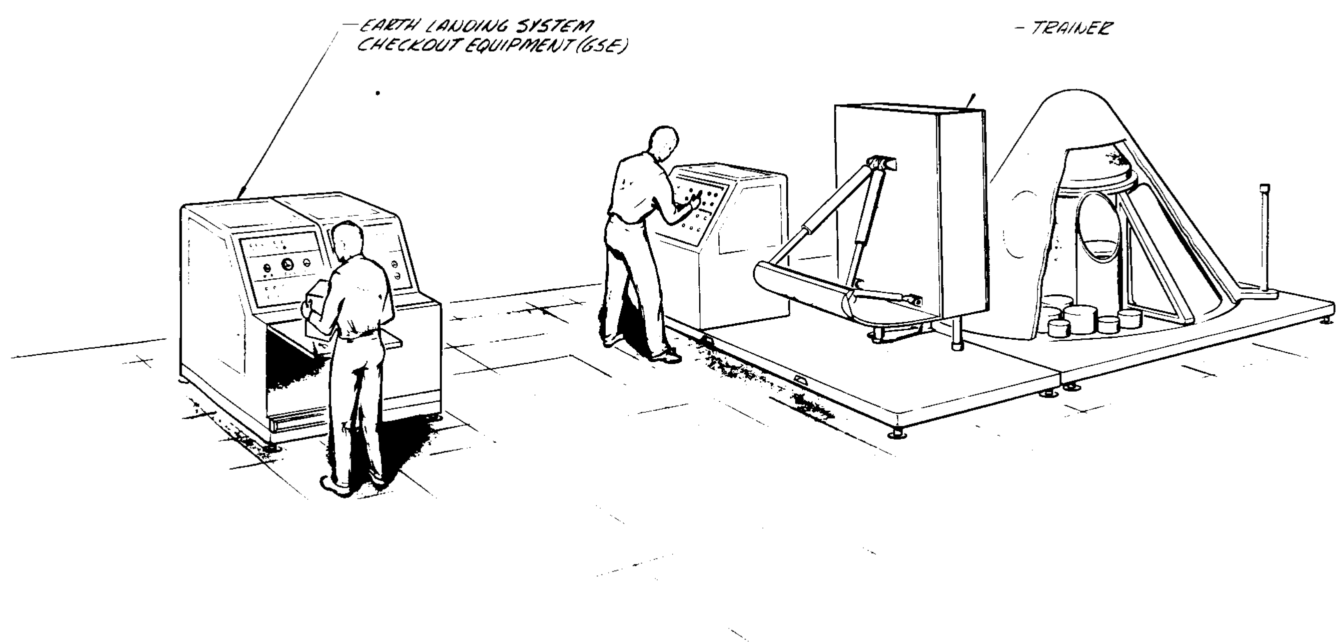

DROGUE CHUTE CAN COVER
TYP. 2 PLACES
INSTRUCTOR'S CONSOLE
PILOT CONTROLS
INSTRUCTOR CONTROLS
AIRLOCK
TRAINER LIFT
MAIN
DROGUE CHUTE
MORTAR
LOCATION
SHOCK STRUTS
SEPARATION
LINES-HEAT SHIELD
OUTER SURFACE
CREW COMPARTMENT
COMMAND MODULE

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK		

E - TYP 4 PLACES
QUIPMENT)
IABLE FOR ACCESS
IPARTMENTS
TE - TYP 3 PLACES

SE

S



QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA: SPECIFICATION SIZES, NOTES, VENDORS	ZONE	ITEM NO.
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												005
												[illegible]
												[illegible]
												[illegible]
						T14-860019	TRAINER					[illegible]

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
				EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES ON:
DECIMALS: .XX ± .03, .XXX ± .010; ANGLES: ± 30'
HOLES NORED "DRILL"
.013 THRU .040 : +.004 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
DO NOT SCALE PRINT

DR BY P. DOWLEY
CHK BY
APPROVED BY

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER - EARTH LANDING SYSTEM (PARACHUTE) MAINT.

CODE IDENT NO. 03953 | SIZE J | T14-860019

SCALE | SHEET

[redacted]

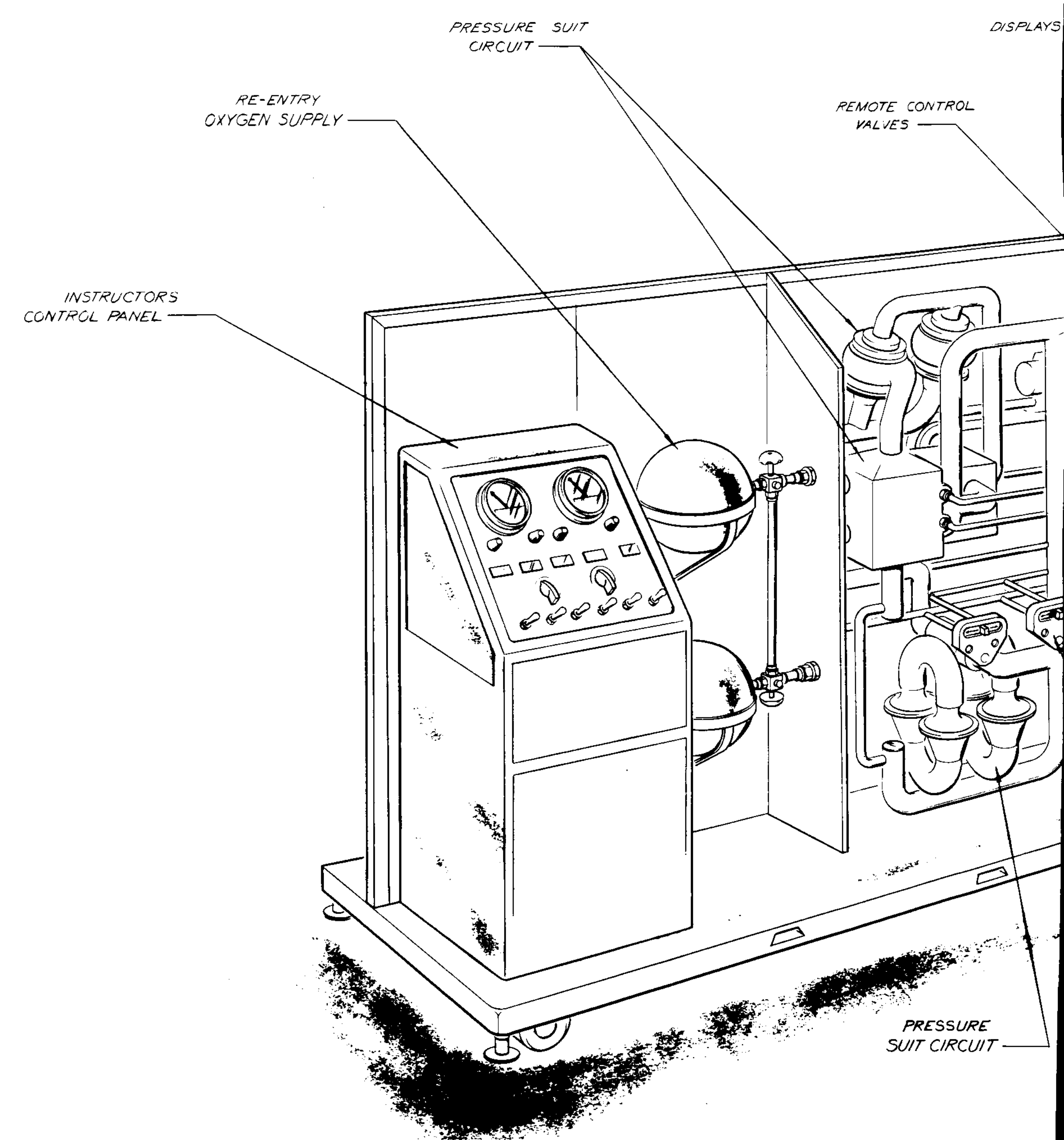
3.4.6 Environmental Control System Trainer (T14-860020)

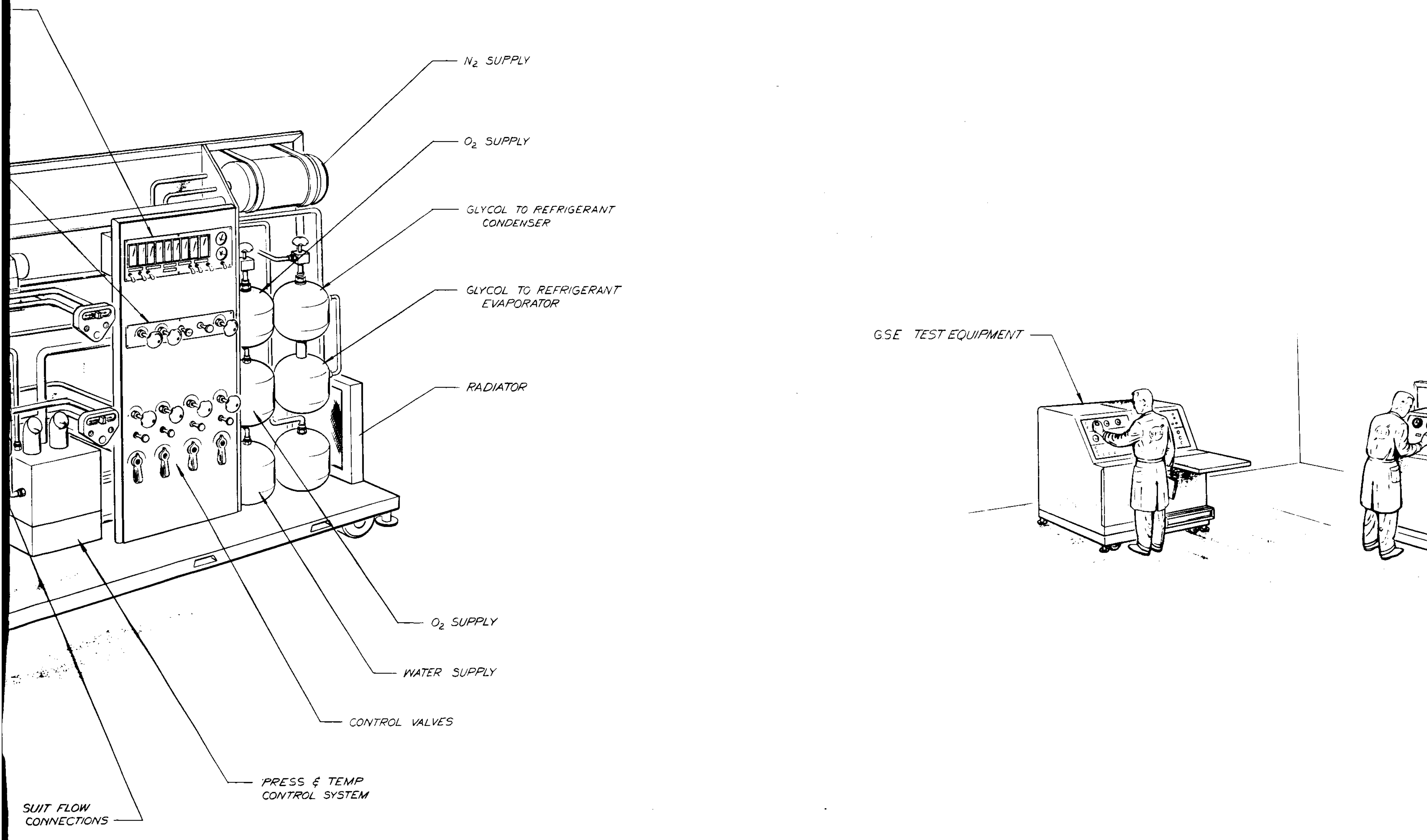
The Environmental Control System Trainer will provide training, through demonstration and practice, in system operation, use of check-out equipment, malfunction isolation, and removal, replacement, and servicing of components. The trainer will consist of the following components:

a. A frame structure supporting system components and/or facsimiles of components, lines and wiring, mounted in the same relative location as in the spacecraft, insofar as practicable. The components will be operable as required by the training need, and may be sectionalized for demonstration of internal operation and servicing. In general, redundant portions of the system will not be included. A trainer operation console will be a part of this section. In this console will be simulation devices which will provide "GO" or malfunction signals to this equipment. The trainer operation console will also incorporate the command module controls and displays, and instructor's malfunction controls.

b. Audio-visual section to present complete system flow, component location, redundant systems, etc. This trainer will back project translucent training material, such as schematics, flow diagrams, component details, etc., on a screen. Motion, where required, will be simulated by polarization methods. The audio section will be synchronized with the individual visual presentations to give descriptive information.

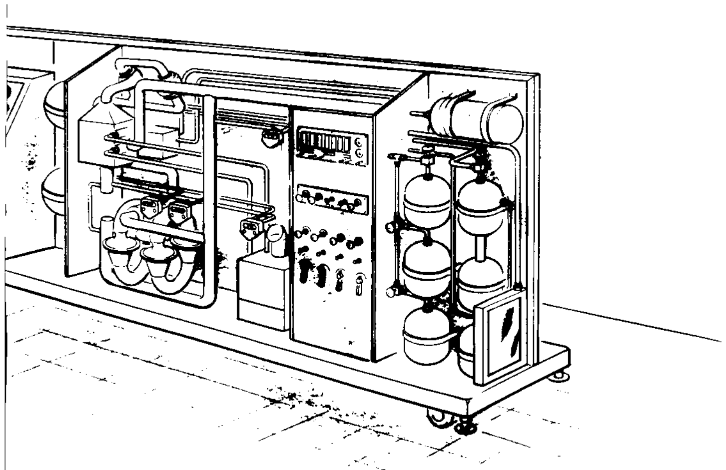
c. GSE checkout equipment.


PRESSURE SUIT
CIRCUIT
DISPLAYS
RE-ENTRY
OXYGEN SUPPLY
REMOTE CONTROL
VALVES
INSTRUCTORS
CONTROL PANEL
PRESSURE
SUIT CIRCUIT


N_2 SUPPLY
O_2 SUPPLY
GLYCOL TO REFRIGERANT CONDENSER
GLYCOL TO REFRIGERANT EVAPORATOR
RADIATOR
O_2 SUPPLY
WATER SUPPLY
CONTROL VALVES
PRESS & TEMP CONTROL SYSTEM
SUIT FLOW CONNECTIONS
GSE TEST EQUIPMENT

REVISIONS

SYM	ZONE	DESCRIPTION	DISPOS	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK			



QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA SPECIFICATION SIZES, NOTES, VENDORS	ZONE	LINE NO.
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							T14 860020	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
REQD PER END ITEM				EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:

DECIMALS	ANGLES
.XX= ± .03	
.XXX= ± .010	± 30'

HOLES NOTED "DRILL"

.013 THRU .040	+ .001 - .001
.041 THRU .130	+ .002 - .001
.131 THRU .229	+ .003 - .001
.230 THRU .500	+ .004 - .001
.501 THRU .750	+ .005 - .001
.751 THRU 1.000	+ .007 - .001
1.001 THRU 2.000	+ .010 - .001

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CHK BY

APPROVED BY [signatures]

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD. DOWNEY, CALIFORNIA

TRAINER- ENVIRONMENTAL CONTROL SYSTEM MAINTENANCE

CODE IDENT NO.	SIZE	
03953	J	T14-860020

SCALE SHEET

[redacted]

3.4.7 Electrical Power System Trainer (T14-860021)

The Electrical Power System Trainer will provide training, through demonstration and practice, in fuel cell charging, operation, and management; and power distribution system operation and checkout. The trainer will consist of the following sections:

a. A suitable base structure supporting operable fuel cell components, including H_2, O_2, and N_2 containers, one fuel cell, an adjustable load bank, and remote controls. To afford practice in handling procedures, the H_2, O_2, and N_2 containers may be filled and drained by use of the appropriate GSE transfer units. The fuel cell will be completely operable through the load bank, and will be controlled from a remotely located trainer console. Due to the critical nature of the fuel cells, no malfunctions will be inserted. ??

b. A fuel cell management section, which will include a crew station console ~~and~~ an instructor's console. The crew station console will present the command module controls and displays, so that the critical fuel cell system management functions may be demonstrated and practiced. These controls and displays will include those, for example, for O_2, H_2, and N_2 pressures, electrolyte temperatures, O_2 and H_2 flow, radiator temperatures, radiator flow, and water temperature and flow. The instructor's console will incorporate simulation equipment to inject indications of malfunctions, which might possibly occur in the spacecraft, into the crew console displays, so that instruction in proper remedial actions may be accomplished.

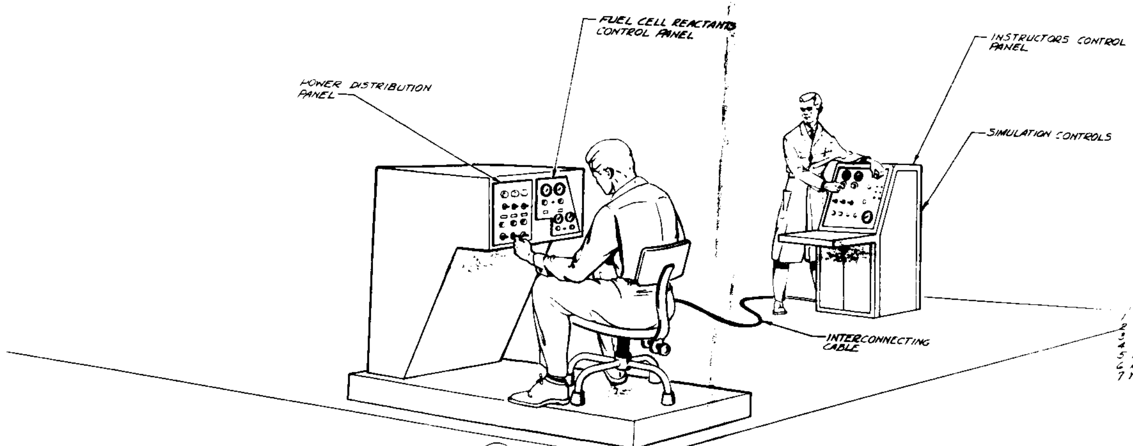
[redacted]

[redacted]

c. A vertical display, on which will be mounted the power distribution system components. The distribution system will be fully operable, except that bus loads will be represented by illumination. This section will incorporate provisions for system checkout, and will include instructor's controls for the insertion of indications of malfunctions or abnormal conditions.

d. GSE as required.

e. Power supply equipment as required.

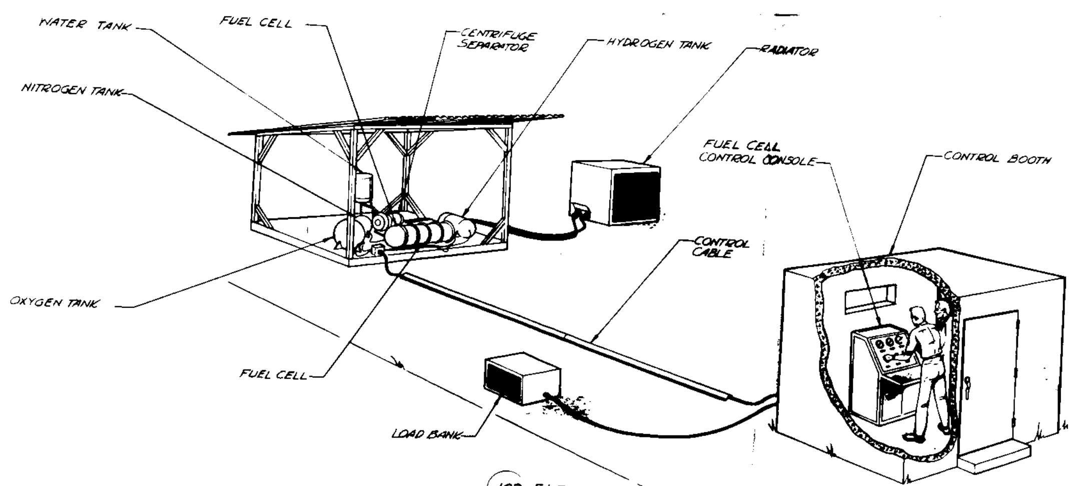


SIMULATED FUEL CELL INDICATIONS, TANK CAPACITYS, PRESSURES, FLOW AND TEMPERATURES WILL BE BY INTEGRATED ELECTRO-MECHANICAL AND SERVO ACTION, ABNORMAL AND EMERGENCY CONDITIONS MAY BE INSERTED BY THE INSTRUCTOR, SIMULATION UNITS WILL BE HOUSED IN THE INSTRUCTORS CONSOLE

FUEL CELL MANAGEMENT TRAINER

IT IS NECESSARY TO MONITOR THE FOLLOWING
1 TANK CAPACITY OF OXYGEN AND HYDROGEN
2 TANK PRESSURE OF OXYGEN HYDROGEN, NYTROGEN
3 TEMPEBATURE OF ELECTROLYTE
4 FLOW OF OXYGEN AND HYDROGEN
5 RADIATOR TEMPERATURE IN AND OUT
6 RADIATOR FLOW (GAS)
7 WATER TEMPERATURE AND FLOW

-105 TRAINER POWER SUPPLY
SIMULATED FUEL CELL CONTROL

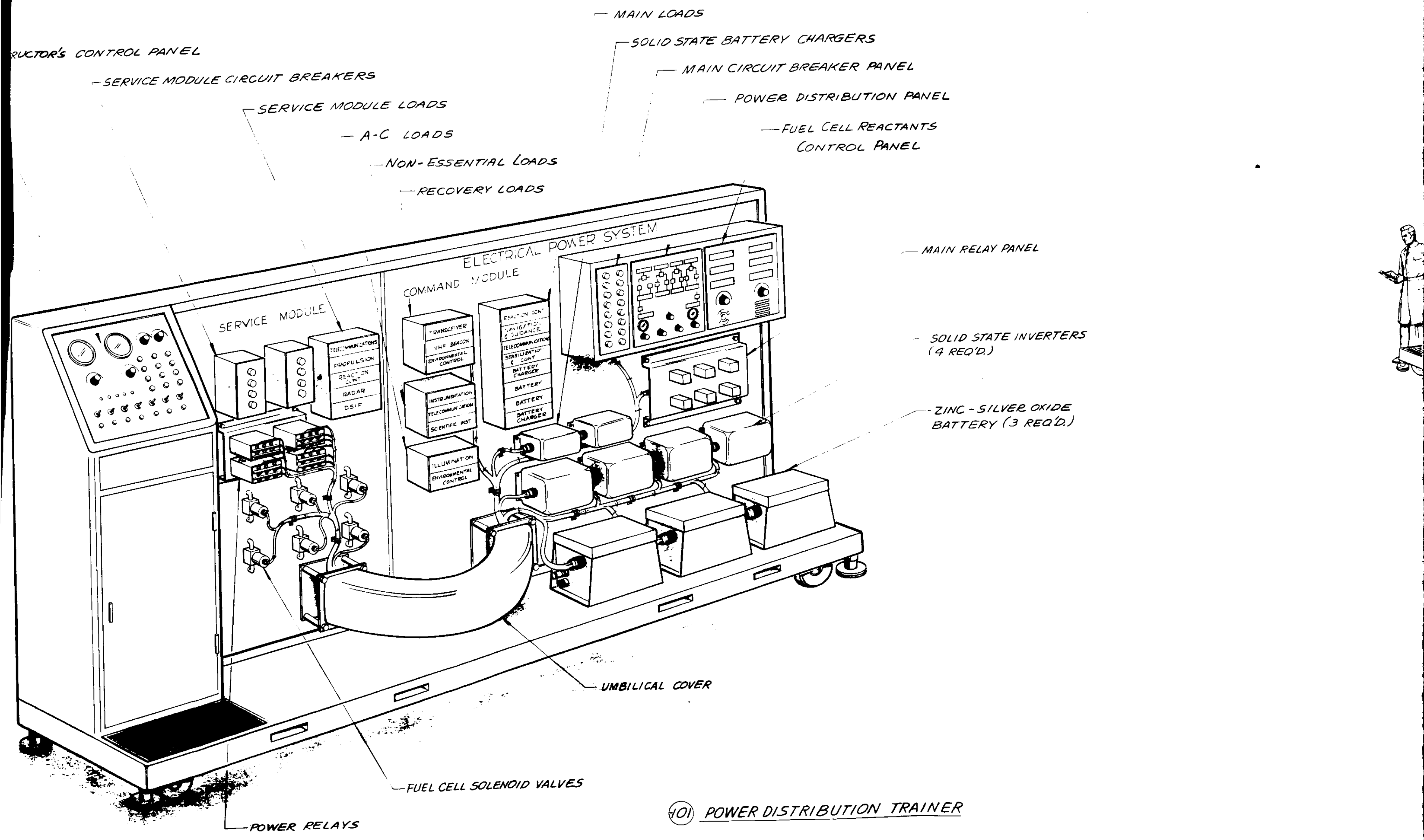


OPERABLE FUEL CELL TRAINER

THE OPERABLE FUEL CELL WILL TRAIN MAINTENANCE PERSONNEL IN SERVICING, INSPECTION, MAINTENANCE AND MONITORING OF FUEL CELL OXYGEN AND HYDROGEN TANK CAPACITYS, OXYGEN, HYDROGEN, NYTROGEN TANK PRESSURES, ELECTROLYTE TEMPERATURE, FLOW OF OXYGEN HYDROGEN, RADIATOR GAS FLOW WATER FLOW AND TEMPERATURE ALSO CURRENT FLOW AND VOLTAGES

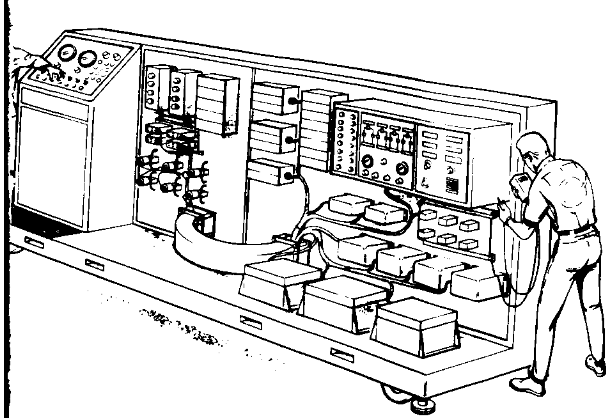
-103 ELECTRICAL POWER SYSTEM
OPERATIONAL FUEL CELL

— INS



(401) POWER DISTRIBUTION TRAINER

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 2. CANNOT BE REWORKED 3. RECORD CHANGE 4. NOW SHOP PRACTICE 5. PARTS MADE OK		



-101 POWER DISTRIBUTION TRAINER

THE POWER DISTRIBUTION TRAINER WILL CONSIST OF POWER DISTRIBUTION COMPONENTS.
INCLUDED WILL BE THE NECESSARY DISPLAY PANELS, BATTERIES, POWER RELAYS, CIRCUIT BREAKER PANELS, SOLID STATE INVERTERS, BATTERY CHARGERS, FUEL CELL SOLENOID VALVES AND UMBILICAL CONNECTIONS.
POWER LOADS WILL BE PORTRAYED BY ILLUMINATED PANELS.
THIS TRAINER WILL TRAIN MAINTENANCE PERSONNEL IN SYSTEM CHECKOUT, QUALIFICATION AND ANALYTICAL TROUBLE SHOOTING.

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA: SPECIFICATION SIZES, NOTES, VENDORS	ZONE	LINE NO.
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						-103	ASS'Y. OF					003
						-101	ASS'Y. OF					002
						T14-860021	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON: DECIMALS .XX = ± .03 .XXX = ± .010 ANGLES ± 30' HOLES NOTED "DRILL" .013 THRU .040 : + .001 - .001; .041 THRU .130 : + .002 - .001; .131 THRU .229 : + .003 - .001; .230 THRU .500 : + .004 - .001; .501 THRU .750 : + .005 - .001; .751 THRU 1.000 : + .007 - .001; 1.001 THRU 2.000 : + .010 - .001

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SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER-ELECTRICAL POWER SYSTEM MAINTENANCE

CODE IDENT NO. 03953 | SIZE J | T14-860021

SCALE NONE | SHEET

[redacted]

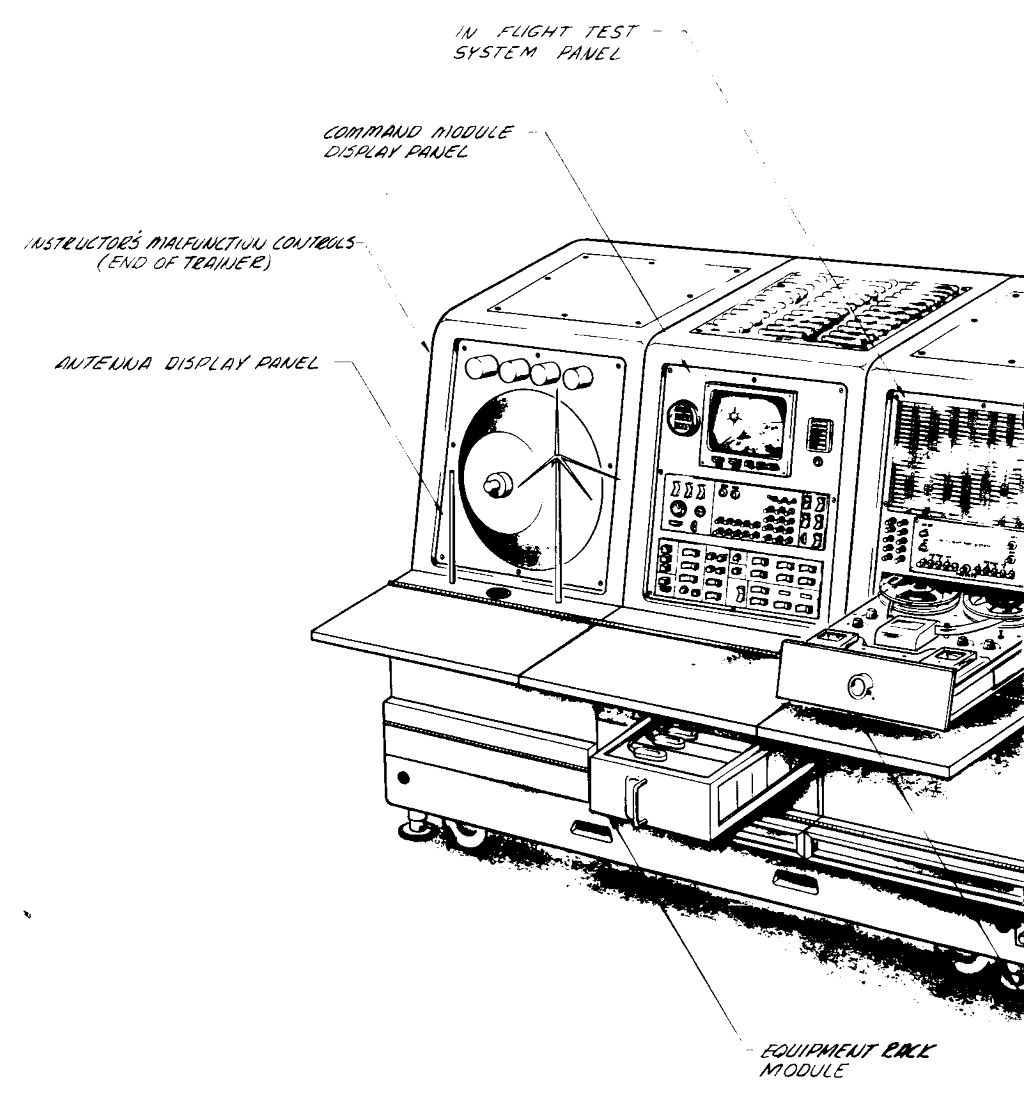
3.4.8 Communications System Trainer (T14-860022)

The Communications System Trainer will provide training, through demonstration and practice, in system operation, checkout, use of related GSE, and removal and replacement of components. The trainer will consist of the following major sections:

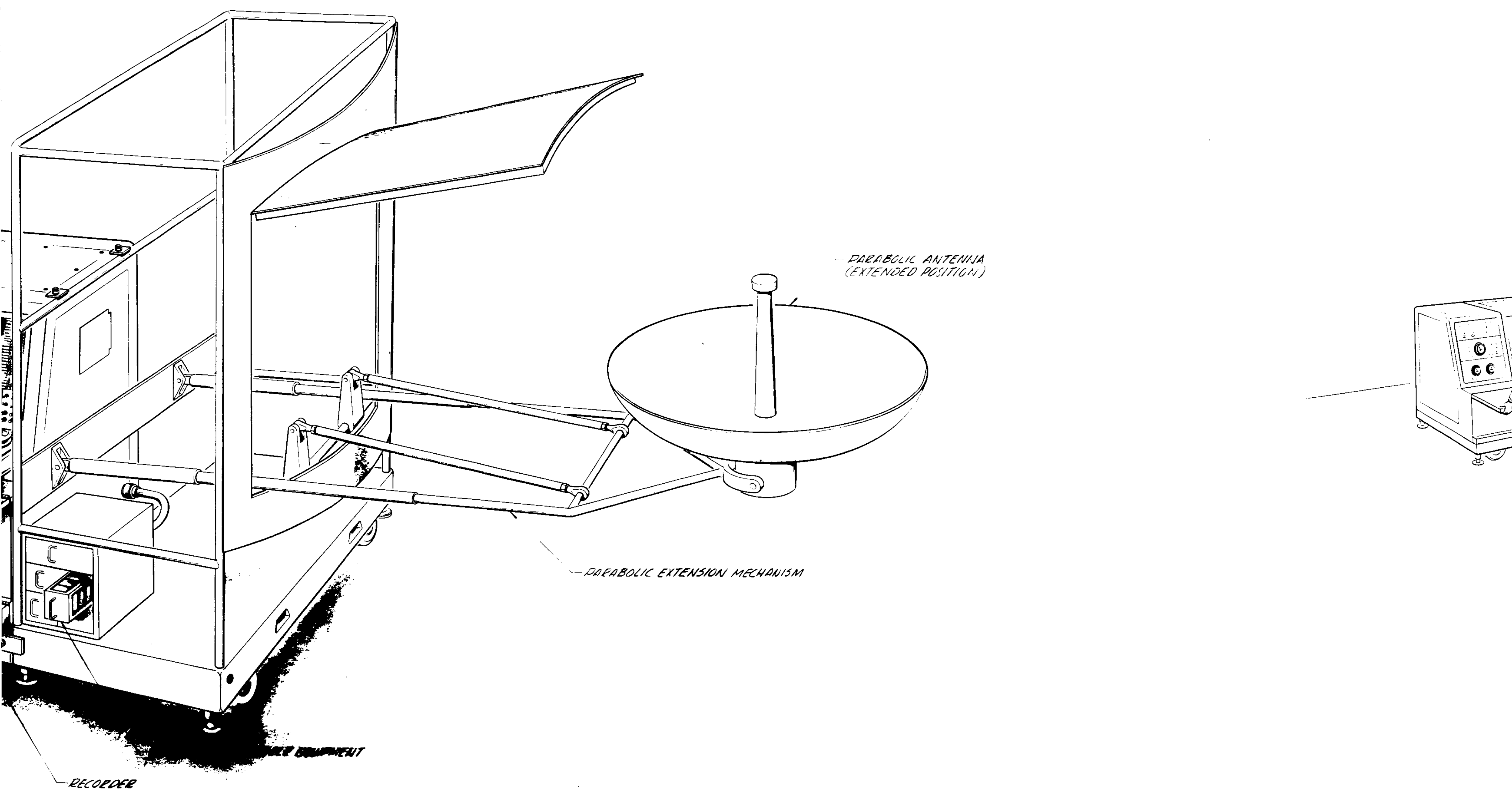
a. A console-type trainer, mounting system components or facsimile equipment. Components will be operable, and facsimiles will incorporate such simulation as required to provide correct indications for system checkout. Typical antennas, including the large parabolic antenna with its extension mechanism and controls, will be incorporated in the trainer. Redundant systems will not be included. A trainer operation panel will be a part of the console, and will include instructor controls for insertion of simulation interface signals, and malfunctions as required by the training need.

b. GSE checkout console.

C. Power supply equipment.


IN FLIGHT TEST
SYSTEM PANEL
COMMAND MODULE
DISPLAY PANEL
INSTRUCTOR'S MALFUNCTION CONTROLS
(END OF TRAINER)
ANTENNA DISPLAY PANEL
EQUIPMENT RACK
MODULE

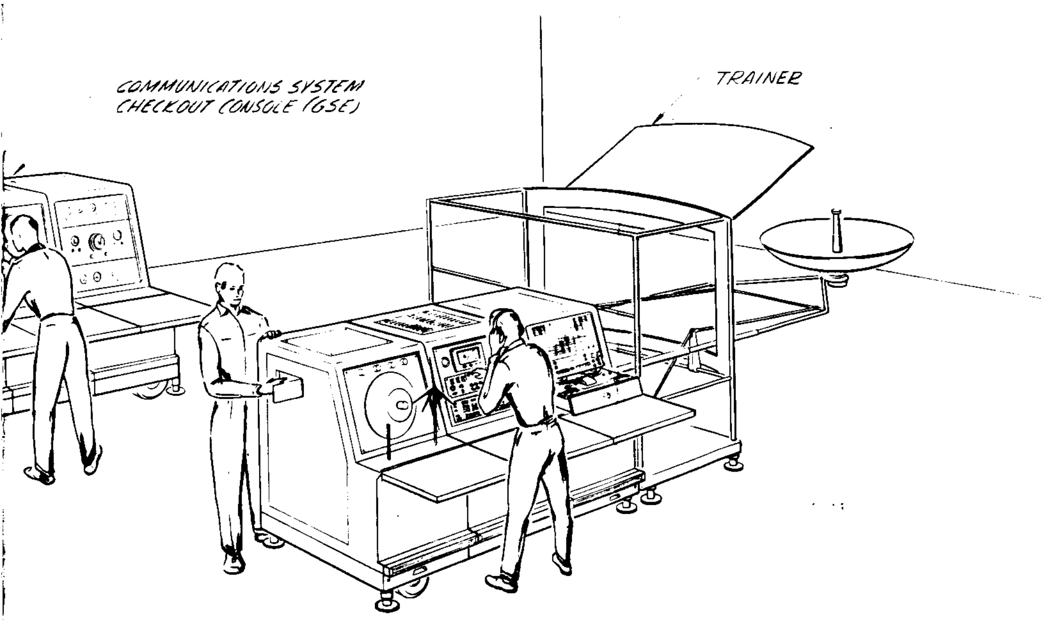
2 of 3


PARABOLIC ANTENNA
(EXTENDED POSITION)
PARABOLIC EXTENSION MECHANISM
RECORDER

3 of 3

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK		



COMMUNICATIONS SYSTEM
MAINTENANCE TRAINING EQUIPMENT

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						T-14-860022	TRAINER					001
QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA: SPECIFICATION SIZES, NOTES, VENDORS	ZONE	LINE NO.

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU
				EFFECTIVE ON	

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS .XX= ± .03 .XXX= ± .010 ANGLES ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
DO NOT SCALE PRINT

DR BY [signature] 5-2-62
CHK BY
APPROVED BY [signatures]

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SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER-COMMUNICATIONS SYSTEMS

CODE IDENT NO. 03953 | SIZE J | T-14-860022

SCALE | SHEET

3.4.9 Instrumentation System Trainer (T14-860023)

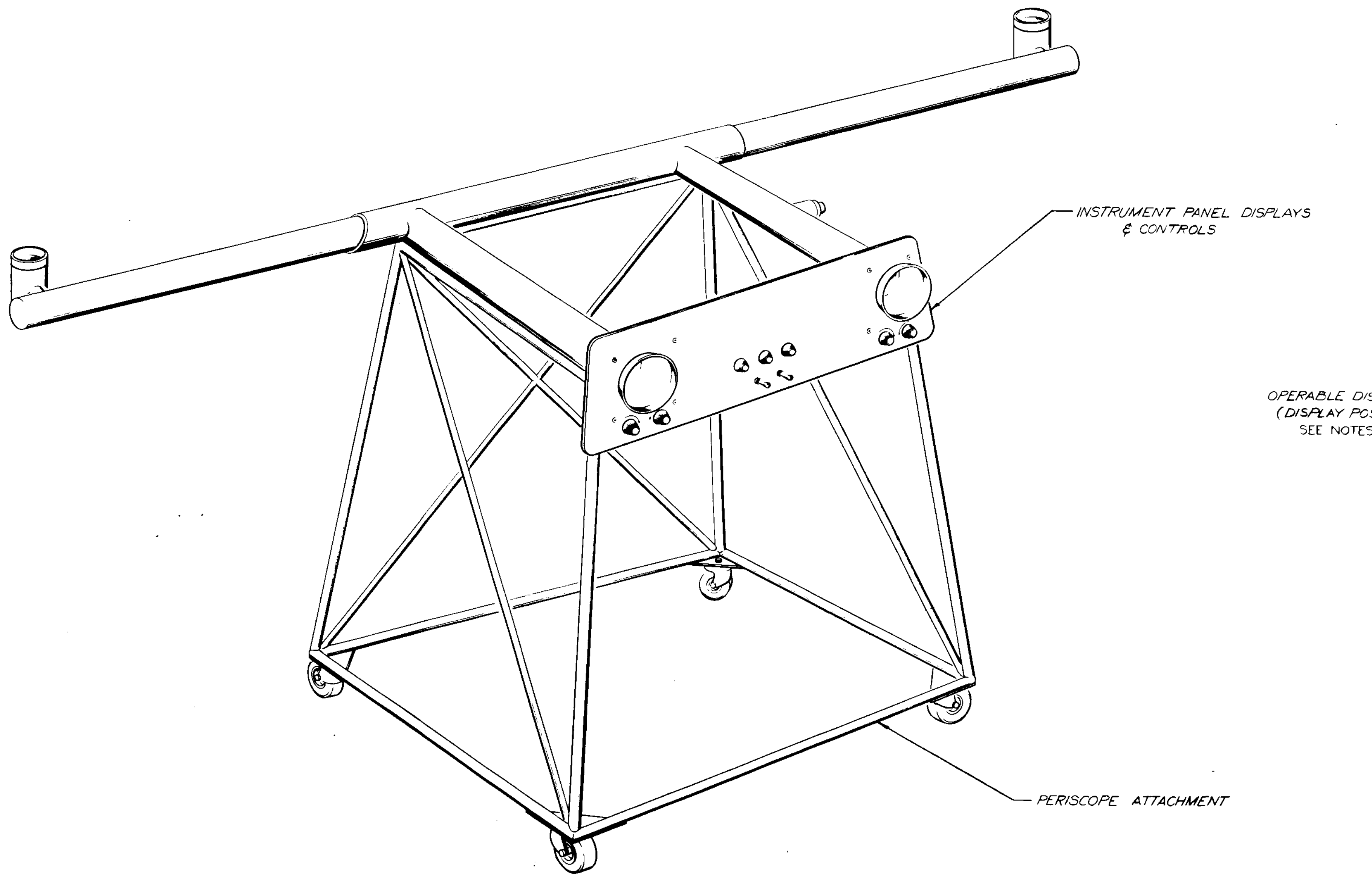
The Instrumentation System Trainer will provide training, through demonstration and practice, in the operation and checkout of instrumentation systems which are not included as integral portions of other system trainers, e.g. radiation detection, bio-medical, etc. The trainer will consist of the following components:

a. A console type trainer, mounting actual components, facsimiles, or schematic presentations on interchangeable panels. Racks will be provided for stowing the panels when not in use. Trainer controls will be provided to inject malfunctions and simulated signals into the various sub-systems for demonstration and checkout. A test bench surface will be provided for checkout of individual components. Provisions for interconnection with GSE checkout consoles will be incorporated.

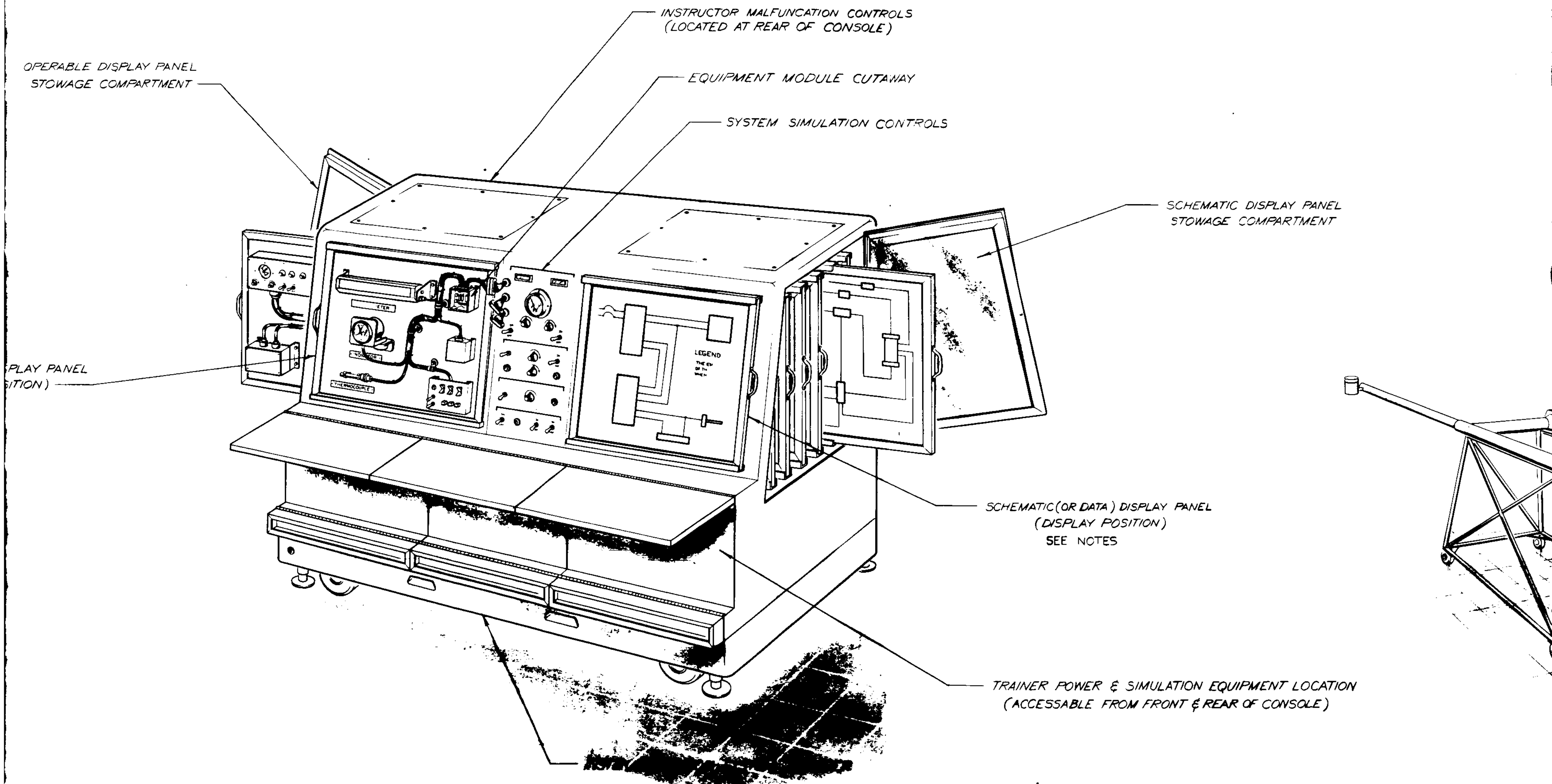
b. A frame structure supporting the periscope for use in instruction in alignment and adjustment.

c. GSE as required.

d. Power supply equipment as required.

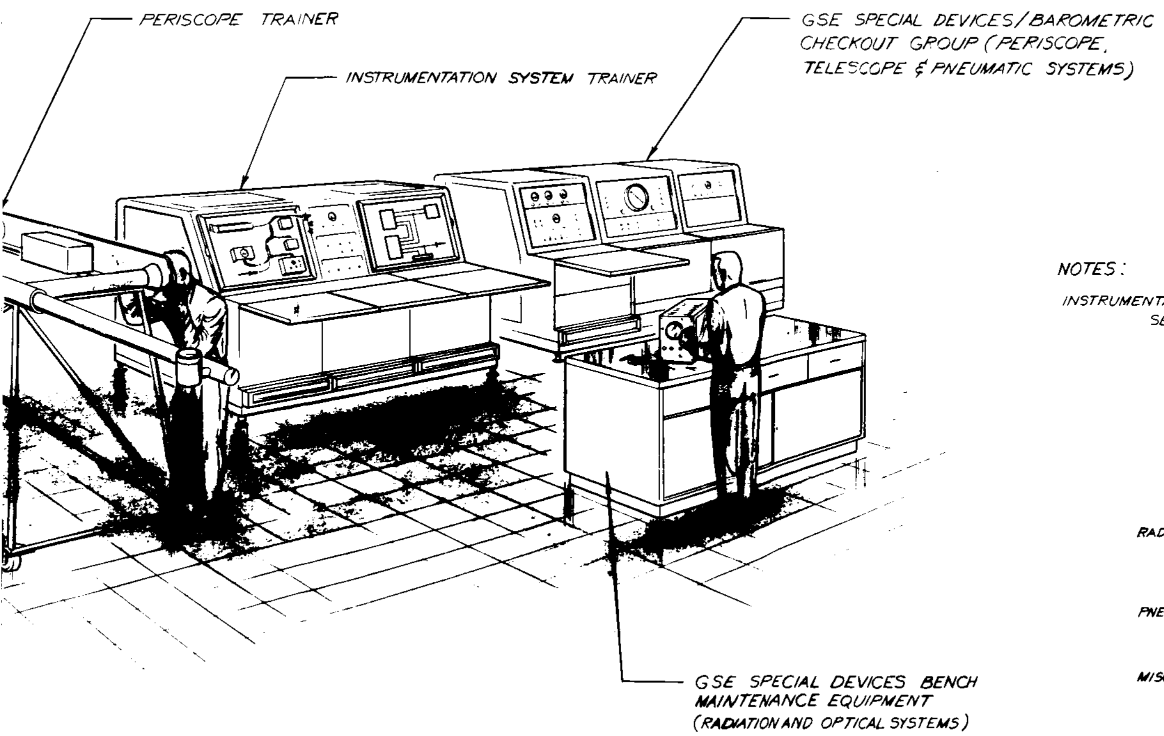

INSTRUMENT PANEL DISPLAYS
& CONTROLS
OPERABLE DIS
(DISPLAY POS
SEE NOTES
PERISCOPE ATTACHMENT

#2 of 3


INSTRUCTOR MALFUNCATION CONTROLS
(LOCATED AT REAR OF CONSOLE)
OPERABLE DISPLAY PANEL
STOWAGE COMPARTMENT
EQUIPMENT MODULE CUTAWAY
SYSTEM SIMULATION CONTROLS
SCHEMATIC DISPLAY PANEL
STOWAGE COMPARTMENT
LEGEND
THERMOCOUPLE
SCHEMATIC (OR DATA) DISPLAY PANEL
(DISPLAY POSITION)
SEE NOTES
TRAINER POWER & SIMULATION EQUIPMENT LOCATION
(ACCESSABLE FROM FRONT & REAR OF CONSOLE)

#3 of 3

REVISIONS					
SYM	ZONE	DESCRIPTION	DISPOS	DATE	APPROVED
		1. MAY BE REWORKED 2. CANNOT BE REWORKED 3. RECORD CHANGE 4. NOW SHOP PRACTICE 5. PARTS MADE OK			



NOTES:

INSTRUMENTATION SYSTEM DISPLAYS –
SENSOR SYSTEMS –

MEASUREMENTS	—	INCLUDING TEMPERATURE, PARTIAL GAS PRESSURE, PRESSURE, ACCELERATION, FLOW QUANITY (FUEL) VIBRATION, SOUND LEVEL, AND BIO-MEDICAL
TYPES	—	SELECTED TYPES TYPICAL OF THE VARIOUS SYSTEMS AND MEASUREMENTS INCLUDING STRAIN GAGE, THERMISTOR ELECTRODE, AND CRYSTAL
RADIATION DET SYS	—	INCLUDING DETECTORS (CHARGED PARTICLE NEUTRON AND GAMMA) SCINTILLATION COUNTERS AND DISPLAYS AS REQUIRED BY SYSTEM DESIGN
PNEUMATIC SYSTEMS	—	INCLUDING PRESSURE ALTIMETER AIRSPEED INDICATOR, AND SUCH OTHER BAROMETRIC DEVICES AS EVOLVE FROM SYSTEM DESIGN
MISC. INSTRUMENTS	—	THOSE INSTRUMENTS OR SYSTEMS NOT APPLICABLE OR ADEQUATELY COVERED UNDER THE VARIOUS MAINTENANCE SYSTEM TRAINERS WHERE A DEFINITE TRAINING NEED IS ESTABLISHED
SCHEMATIC/DATA DISPLAYS	—	THESE PANELS DEPICT THE SYSTEM WIRING, DATA FLOW, OR CALIBRATION DATA

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA: SPECIFICATION SIZES, NOTES, VENDORS	ZONE	LINE NO.
						T14-860023	TRAINER					001

LIST OF MATERIAL OR PARTS LIST

ITEM REQD	QTY PER END ITEM	MODEL	NEXT USING ASSEMBLY	END ITEM NO.	THRU EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON: DECIMALS .XX = ±.03 .XXX = ±.010 ANGLES ±30' HOLES NOTED "DRILL" .013 THRU .040 : +.001 -.001 .041 THRU .130 .131 THRU .220 .230 THRU .500 : +.004 -.001 .501 THRU .750 : +.005 -.001 .751 THRU 1.000 : +.007 -.001 1.001 THRU 2.000 : +.010 -.001

DO NOT SCALE PRINT

DR BY K. Kosen 3-4-64

CHK BY

APPROVED BY

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER-INSTRUMENTATION SYSTEM MAINTENANCE

CODE IDENT NO.	SIZE	
03953	J	T14-860023

SCALE SHEET

[redacted]

3.4.10 Navigation and Guidance System Trainer (T14-860024)

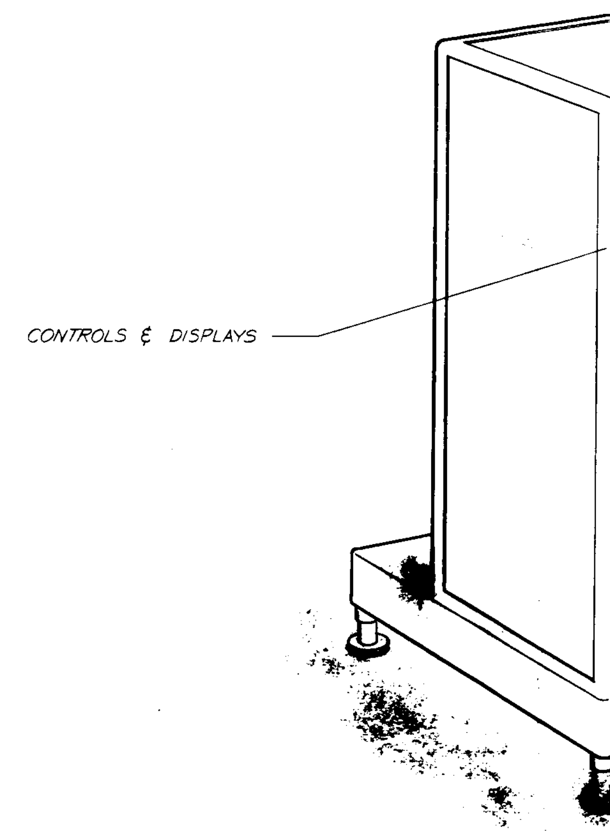
The Navigation and Guidance System Trainer will provide training, through demonstration and practice, in system operation, checkout, qualification, and analytical trouble shooting. The trainer will consist of the following sections:

a. A console type structure mounting the system components in their proper relative location; command module displays, and trainer operation controls and equipment. The system components and displays will be operable, and provisions will be made for interconnection with the system GSE checkout equipment. Simulation equipment will be incorporated so that malfunction indications may be injected.

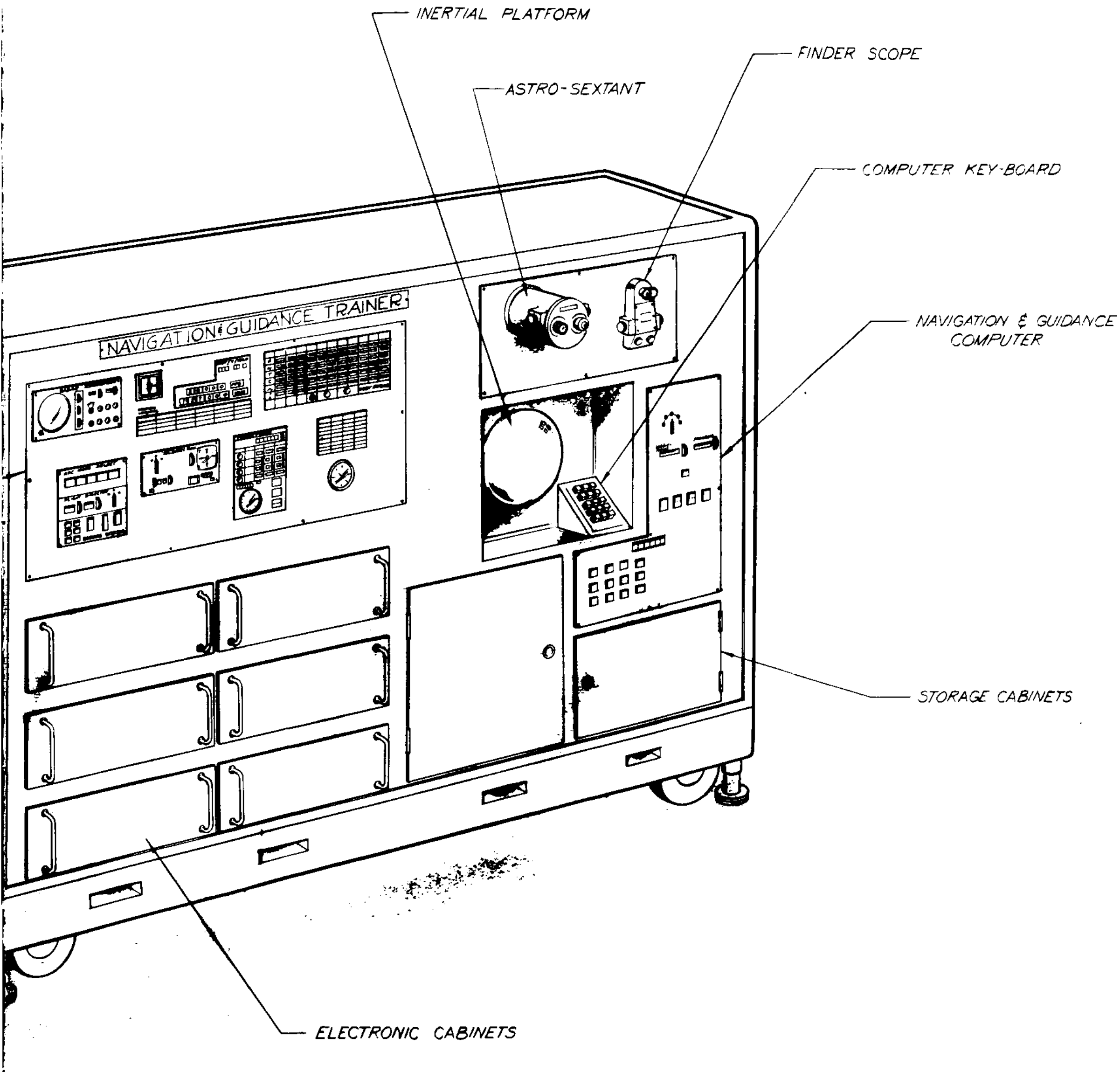
b. Audio-visual section to present data flow, computer operation, alignment techniques, stable platform operation, etc. This trainer will back project translucent training material on a screen. Motion, where required, will be simulated by polarization methods. The audio section will be synchronized with the individual visual presentation to give descriptive information and theory of operation.

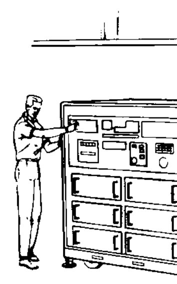
c. GSE checkout equipment.

d. Power supply equipment.


CONTROLS & DISPLAYS

#2 OF 3





NAVIGATION A

#3 of 3

REVISIONS					
SYM	ZONE	DESCRIPTION		DATE	APPROVED
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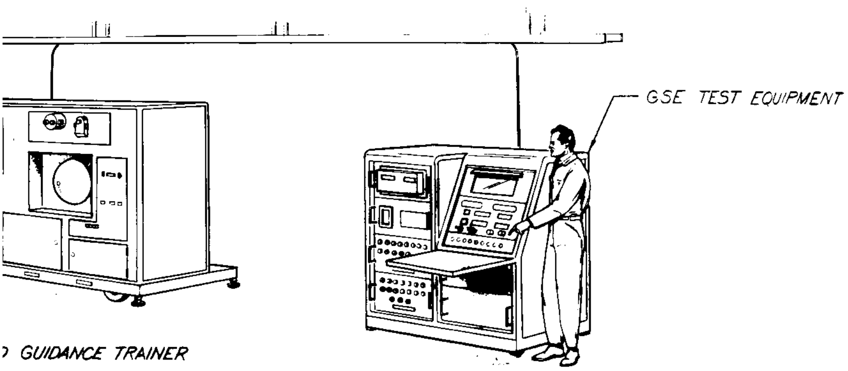

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						T14-860024	TRAINER					001
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LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS: .XX = ± .03; .XXX = ± .010. ANGLES: ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
.131 THRU .229 : +.003 -.001
.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
DO NOT SCALE PRINT

DR BY E.J. MCDERMOTT 3-17-62
CHK BY
APPROVED BY

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION
12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER-NAVIGATION AND GUIDANCE SYSTEM, MAINTENANCE

CODE IDENT NO. 03953 SIZE J T14-860024

SCALE SHEET

[redacted]

3.4.11 Stabilization and Control System Trainer (T14-860025)

The Stabilization and Control System Trainer will provide training, through demonstration and practice, in system operation, checkout, qualification, and analytical trouble-shooting. The trainer will consist of the following components:

a. A console type structure mounting the system components in their proper relative locations; command module displays, manual control system components; and trainer operation controls and equipment. The system components and displays will be operable in conjunction with GSE checkout consoles, and selected malfunction signals may be injected.

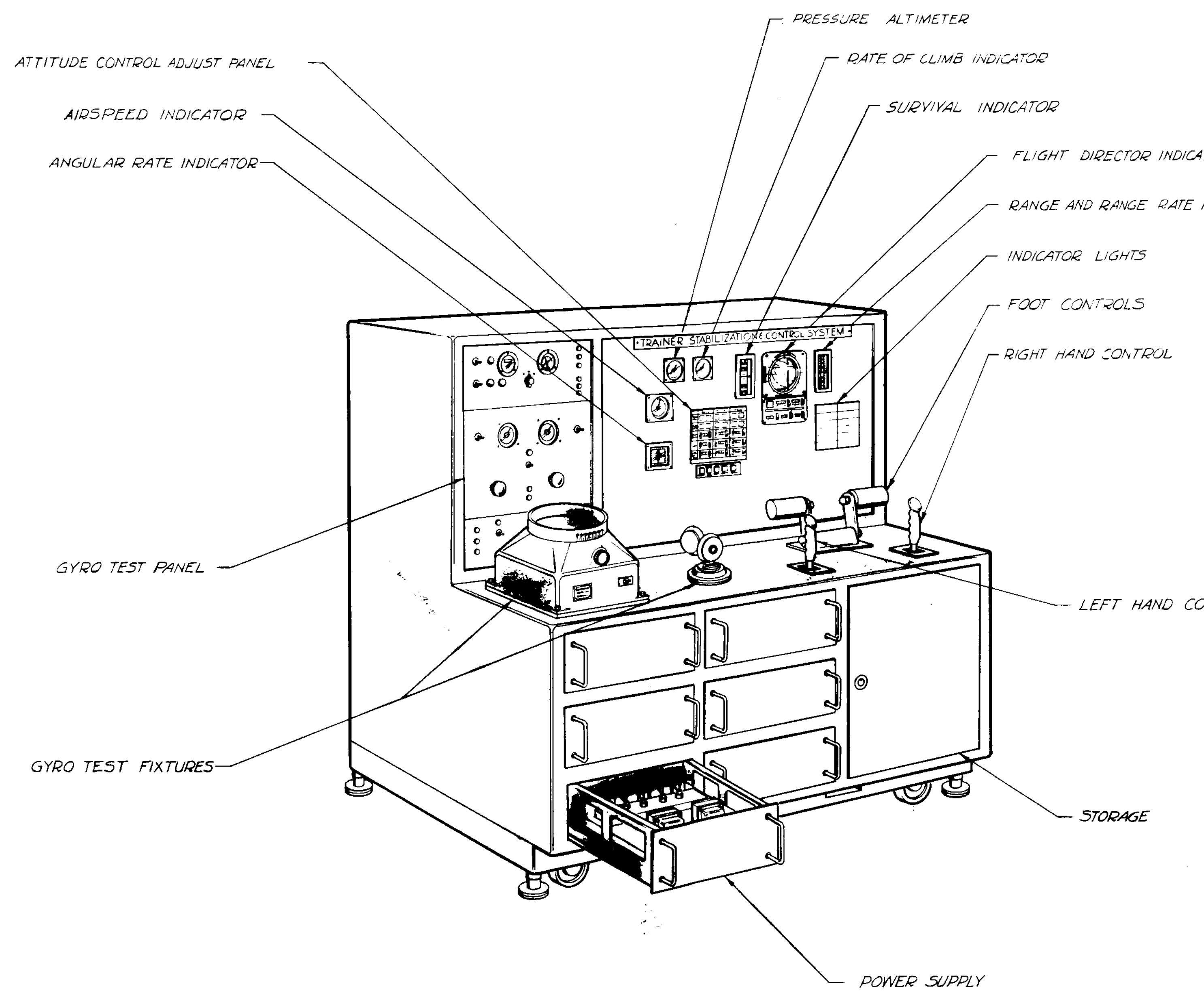
b. A gyro rate table and associated control and test equipment for demonstration and practice in checking and qualifying the system gyros.

c. Audio-visual section to present data flow, computer operation, alignment techniques, etc. This trainer will back project translucent training material on a screen. Motion, where required, will be simulated by polarization methods. The audio section will be synchronized with the individual visual presentation to give descriptive information and theory of operation.

d. GSE checkout consoles.

e. Power supply equipment as required.

1 of 2


PRESSURE ALTIMETER
RATE OF CLIMB INDICATOR
SURVIVAL INDICATOR
FLIGHT DIRECTOR INDICATO
RANGE AND RANGE RATE IN
INDICATOR LIGHTS
FOOT CONTROLS
RIGHT HAND CONTROL
ATTITUDE CONTROL ADJUST PANEL
AIRSPEED INDICATOR
ANGULAR RATE INDICATOR
TRAINER STABILIZATION & CONTROL SYSTEM
GYRO TEST PANEL
LEFT HAND CON
GYRO TEST FIXTURES
STORAGE
POWER SUPPLY

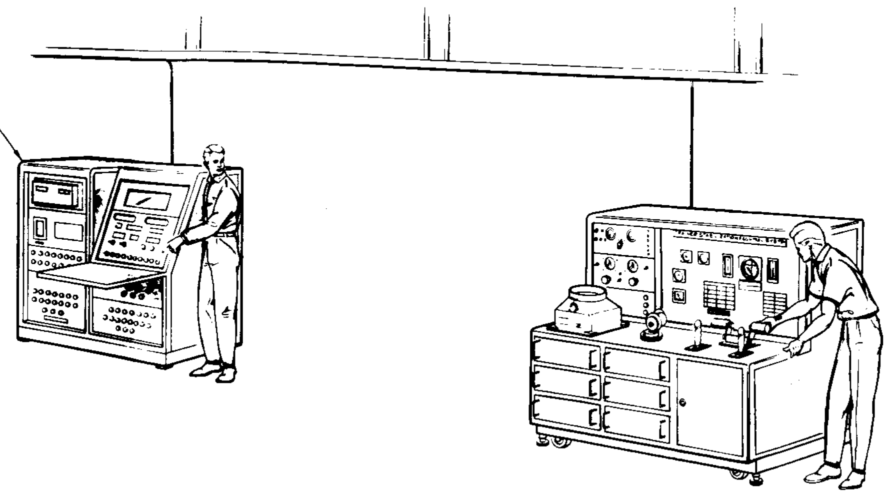
SYM	ZONE	DESCRIPTION	DISP	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK			

OR

ICATOR

TROL

GSE TEST EQUIPMENT



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						T14-860025	TRAINER					

LIST OF MATERIAL OR PARTS LIST

ITEM	QTY REQD PER END ITEM	MODEL	NEXT USING DRAWING	END ITEM NO.	THRU EFFECTIVE ON

APPLICATION (USAGE) DATA

HEAT TREAT

FINISH

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ON:
DECIMALS .XX= ± .03 .XXX= ± .010 ANGLES ± 30'
HOLES NOTED "DRILL"
.013 THRU .040 : +.001 -.001
.041 THRU .130 : +.002 -.001
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.230 THRU .500 : +.004 -.001
.501 THRU .750 : +.005 -.001
.751 THRU 1.000 : +.007 -.001
1.001 THRU 2.000 : +.010 -.001
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12214 LAKEWOOD BLVD., DOWNEY, CALIFORNIA

TRAINER - STABILIZATION & CONTROL SYSTEM MAINTENANCE

CODE IDENT NO. 03953 | SIZE J | T14-860025

SCALE | SHEET